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WATER RESOURCES STUDY AND PUBLIC HEALTH ASPECTS OF THE CENTRAL UTAH PROJECT--BONNEVILLE UNIT, UTAH

Public Health Service
Denver, Colorado

July 1963

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WATER RESOURCES STUDY
and
PUBLIC HEALTH ASPECTS
of the
CENTRAL UTAH PROJECT -- BONNEVILLE UNIT
UTAH

Study of Potential Needs and Value of Water for the
Purpose of Water Quality Control and the Public Health Aspects
of the Central Utah Project, Bonneville Unit - Utah
Bureau of Reclamation - Region 4

U. S. Department of Health, Education, and Welfare
Public Health Service, Region VIII
Division of Water Supply and Pollution Control
Denver, Colorado

In Cooperation with The
Bureau of Reclamation, Region 4
Salt Lake City, Utah

FEBRUARY 1963

(Revised July 1963)

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PART A - WATER RESOURCES STUDY

I. INTRODUCTION

Authorization

In accordance with the memorandum of understanding dated September 28, 1956, between the Bureau of Reclamation, Region 4, Department of the Interior, and the Public Health Service, Department of Health, Education, and Welfare, consideration has been given to the general public health aspects of the Bureau of Reclamation's proposed Central Utah Project. Following a meeting of representatives of the two agencies on August 2, 1962, and under terms of a subsequent letter of authorization dated August 14, 1962, the inter-agency agreement was broadened to recognize Public Health Service responsibilities set forth in Section 2(b) of the Federal Water Pollution Control Act, (Public Law 660, 84th Congress, as amended by Public Law 87-88, approved July 20, 1961.)

Purpose and Scope

General objectives of this study are to assess the probable effects of project construction and operation on water quality in local streams and lakes; to ascertain the benefits or harm resulting from changes in water quality, and finally to examine the need for regulation of streamflow for the purpose of water quality control in the principal streams affected. Need for regulation of streamflow was studied not only in light of present conditions, but also under anticipated economic development of the years 1985, 2010, and 2060.

The report includes the results of a study of general public health aspects and insect vector control of the project. The insect vector control section, prepared jointly by the Utah State Department of Health, Salt Lake City, Utah and the Communicable Disease Center, Public Health Service, Greeley, Colorado, presents a preliminary evaluation of the insect vector problems that may be associated with the project.

Acknowledgements

The cooperation and assistance of many persons and agencies are gratefully acknowledged by the Public Health Service. Particular appreciation is expressed to the following organizations for data and advice furnished by their staff members:

U. S. Bureau of Reclamation, Region 4,
Salt Lake City, Utah

State of Utah, Department of Public Health,
Bureau of Sanitation, Salt Lake City, Utah

University of Utah, College of Business,
Bureau of Economic and Business Research,
Salt Lake City, Utah

II. SUMMARY AND CONCLUSIONS

Summary

1. The Central Utah Project, Bonneville Unit, is a multiple-purpose project of the Bureau of Reclamation. It provides for the interception and storage of streamflows originating on the southern slope of the Uinta Mountains, as far East as Rock Creek. These waters are to be exported from the Uinta Basin to the Bonneville Basin in north central Utah. In addition to providing water for irrigation, the importation of water from the Colorado River Basin to the Bonneville Basin will release more water from the Provo River for urban water supplies in Salt Lake and Utah counties. Supplemental water supplies will be developed from the Duchesne River and other streams in the Uinta Basin to meet requirements in that basin.

2. Salt Lake and Utah counties constitute the center of industrial and commercial activity in Utah. The remaining counties in the project area are primarily agriculturally oriented.

3. About 97 percent of the 1960 population in the project area was located in the valleys and central trading centers of Salt Lake and Utah counties. Population of the project area increased twice as fast as the United States and about 25 percent faster than the State of Utah from 1940 to 1960.

4. Surface waters are generally used for irrigation. In addition the Provo River is utilized for municipal and industrial water supplies in the Salt Lake City and Provo areas. Utah Lake water is also used for industrial purposes. Migratory waterfowl resting areas and numerous duck-hunting clubs are located in the marsh lands near the mouth of the Jordan River.

5. The project will cause extensive changes in present stream regimes and in quality of water in some of the streams and lakes. The nature of these changes, their affects on water uses, the need for regulation of streamflow for the purpose of water quality control and other public health aspects of the project have been given consideration in this report.

Conclusions

1. The industrial and agricultural resources in the project area constitute a potential for future industrial and municipal growth.

2. If economic development of the project area is to occur, surface water supplies must be developed to meet the anticipated water needs.

3. Technological advancement will lead to fuller utilization of the project area resources and undoubtedly will affect the water requirements of the basin.

4. The project area's population is expected to increase from 506,339 in 1960 to 938,000 by the year 1985; 1,492,000 by the year 2010; and 2,429,000 by the year 2060. The population of the project area is expected to have a faster rate of growth during the next 100 years than the State of Utah and likewise the State is expected to grow at a faster rate than the United States.

5. Mineral quality of Deer Creek and Strawberry Reservoirs will remain essentially unchanged. Concentrations of total dissolved solids in Utah Lake and Mona Reservoirs will be reduced. Average total dissolved solids concentration in Utah Lake will be reduced from 885 to 588 ppm, based on the 1921-60 period; in Mona Reservoir for the period of record, 1954-60, they will be reduced from 980 to 630 ppm.

6. The quality of Provo River water will be virtually unchanged. Spanish Fork River water will be improved in mineral quality during the winter months, November to April, and almost unchanged during the irrigation season, May through October. Benefits from water quality improvements in the Spanish Fork River were not computed because of insufficient data.

7. Duchesne River will be adversely affected by the transmountain diversion of water, however, insufficient data are available at this time to make an evaluation of the negative benefits. (The Duchesne segment is an integral part of the Colorado River Basin now under study by the Colorado River Basin Water Quality Control Project, Public Health Service, Denver, Colorado. One

of the objectives of the basinwide study is to develop a plan for long range comprehensive water quality management. Since this study of the Duchesne segment is being made in advance of the comprehensive study, certain data and preliminary recommendations presented must necessarily await later confirmation.)

8. Locations and conditions under which annual benefits provided by development of the Central Utah Project and additional benefits, if computed streamflow regulation is provided, for the purpose of water quality control are as follows:

   a. Benefits attributable to organic quality improvement with removal of 85% of the BOD.

Location	Automatic Benefits with Project Development	Additional Benefits if computed streamflow regulation is provided	Total Benefits
Utah Lake	$ 15,180	$ 342,270	$ 357,450
Jordan River (at 2100 So.-SLC)	None	74,700	74,700
Subtotal	$ 15,180	$ 416,970	$ 432,150

   b. Benefits attributable to chemical quality improvement.

Utah Lake (irrigation water savings)	$170,820	None	$ 170,820
Salt Lake City (exchange deep wells supply for Provo River)	$ 39,200	None	$ 39,200
Subtotal	$210,020	None	$ 210,020
TOTAL	$225,200	$ 416,970	$ 642,170

All the above described benefits are considered to be widespread in scope with the exception of exchange water for Salt Lake City. The widespread automatic benefits would total $186,000 annually while widespread additional benefits, if computed streamflow regulation is provided, would amount to $416,970 annually for a combined total of $602,970.

If Provo River water could be exchanged for deep well water serving Salt Lake City, then gross savings of $39,200 annually could be expected due to reduction in hardness. However, the present deep well water supply is used near the source for culinary purposes, thus exchange benefits would be local in scope. Data were not available to compare the cost of operation, maintenance, and replacement for the deep well water supply with that of the Provo River supply.

III. DESCRIPTION OF PROJECT AND STUDY AREA

Proposed Project Development (1)(2)

Project developments will affect all or part of seven counties in north central Utah: Salt Lake, Utah, Juab, Wasatch, Duchesne, Summit, and Uintah. For study purposes the project has been divided conveniently into two segments by the Bureau of Reclamation: The Duchesne segment covering developments in that basin east of the Colorado-Great Basin Divide, and the Bonneville segment comprising developments west of this Divide in the Great Basin. The location of reservoirs and lakes, major conveyance system, drainage basins and counties are shown on Figure 1.

In the Duchesne segment surplus flow from the Duchesne Rive will be diverted by a feeder canal to Starvation Reservoir for irrigation of land on the east side of the Divide. This reservoir, to be built on Strawberry River, a short distance upstream from the town of Duchesne, will provide late-season water for irrigation of about 52,000 acres of land, including 20,700 acres owned by Indians.

The plan of development of the Bonneville Unit is very complex. The runoff of several small streams draining the southern slopes of Uinta mountains as far east as Rock Creek will be intercepted and conveyed by gravity to an existing reservoir, Strawberry, which will be enlarged for the purpose. About 135,000 acre-feet of the new supply will be exported annually by transmontane tunnel to Bonneville Basin, as well as 61,000 acre-feet derived from the older Strawberry Project, built in 1915.

Approximately 151,000 acre-feet are to be used for irrigation in the Spanish Fork, Peteetneet and Mona-Nephi areas of Utah and Juab counties. To this will be added 9,000 acre-feet for municipal use.

From 26,000 to 30,000 acre-feet per year of the imported supply will be discharged into Utah Lake, replacing inflow from its tributary, the Provo River. Waters of the Provo River are of better chemical quality than Utah Lake, and their use for irrigation is being discontinued gradually in favor of municipal and industrial use in Salt Lake and Utah counties. About 19,000 acre-feet of Provo River water were used by greater Salt Lake City in 1961. Under the initial phase of the Central Utah Project, 70,000 acre-feet annually will be available for use in the two counties

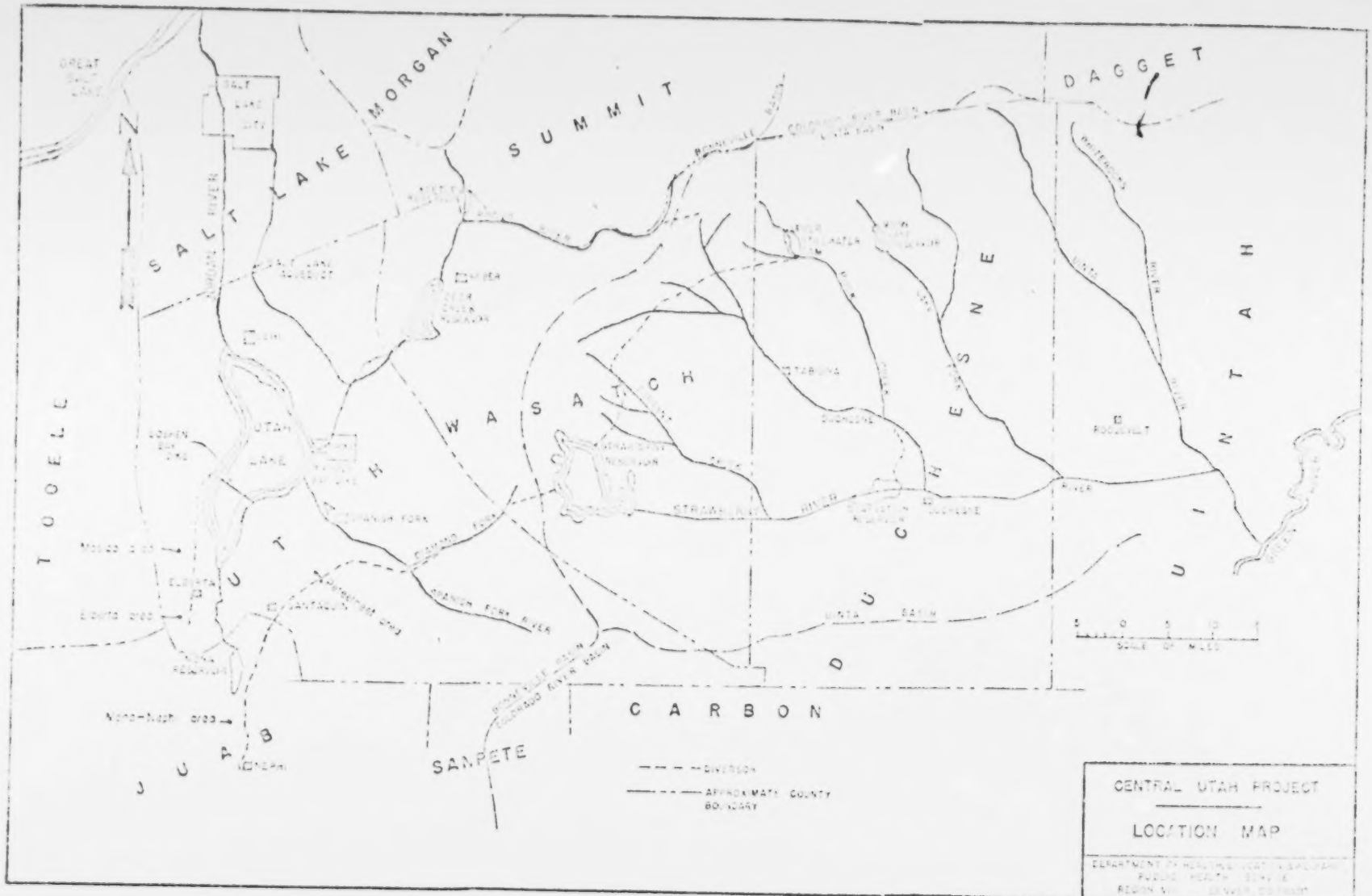
DAGGET
MORGAN
SUMMIT
SALT LAKE
TOOELE
UTAH
WASATCH
DUCHESNE
UINTAH
CARBON
SANPETE
JUAB
UTAH LAKE
STRAWBERRY RIVER
PROVO RIVER
UINTA BASIN
DIVERSION
APPROXIMATE COUNTY BOUNDARY
CENTRAL UTAH PROJECT
LOCATION MAP

FIGURE 1

and this amount is capable of eventual expansion to nearly 100,000 acre-feet. The Provo River development is an essential feature of the project. It will comprise interception of natural flows of the river through provision of additional storage, and the exchange of existing water rights in the river, for project waters stored in Utah Lake. Provo River water will be used largely for urban water supply, for which the lake waters are chemically unsuitable.

The Bureau of Reclamation proposes to conserve some 80,000 acre-feet yearly of water now lost by evaporation from Utah Lake, by diking off two shallow arms of the lake, Provo Bay and Goshen Bay. The water so conserved, and supplemented by return irrigation flows into Utah Lake, will permit irrigation of additional land in the Mosida, Provo and Elberta areas. Construction of the Goshen dike will confer an additional benefit in improving water quality through the exclusion from Utah Lake of highly mineralized return irrigation waters from the Mosida area, and of flow from natural saline springs.

Description of Study Area

Boundaries

For purposes of this study the counties of Salt Lake, Utah, Juab, Wasatch, and Duchesne were considered as the major counties affected by the project. Only a small portion of Summit County would be affected by the project; therefore, it was not included in this report. Uintah County has not been included in this study because the Jensen Unit-Central Utah Project is programmed for a later date.

Location[1]

The Bonneville Unit of Central Utah Project covers portions of two major physiographic provinces and drainage areas, Colorado Basin in the east and Great Basin west of the Wasatch Divide. Principal streams are Strawberry and Duchesne Rivers east of the Divide, and Spanish Fork, Provo, and Jordan Rivers in the west. There are two important storage reservoirs, Strawberry on the river of that name, 270,000 acre-feet of active capacity; and Deer Creek Reservoir on Provo River, 150,000 acre-feet. Utah Lake in Bonneville Basin is the largest body of fresh water in the state, and is a cardinal element in the project for storage and flow regulation.

Soils[1]

The soils of the project area are fertile and productive under irrigation farming. They originated primarily from alluvial material deposited in the valleys by stream action from the various strata of the surrounding hills and mountains. In general, the soils are of medium texture and open structure, having a moderate permeability and good available moisture capacity.

Salinity and Alkalinity[1]

Salinity and alkalinity problems occur in varying amounts in most of the areas. Problem areas are located primarily on bottom lands toward the center of the valleys and in other low-lying areas where drainage is restricted. Some of the problem areas may be reclaimed through drainage while other areas of high salinity and alkalinity were eliminated from the project as nonarable. The project lands are generally free from excessive concentrations of alkali and salts.

Drainage[1]

Drainage problems of varying degrees exist in some of the areas considered for irrigation development. The Beer Creek area occupies the lowlands south of Utah Lake. These lands are presently seeped by high ground water and can be reclaimed only by subsurface drainage. The low-lying lands of the Mona-Nephi area have high ground-water levels which must be controlled through drainage if project development is to be accomplished. The other areas have no visible drainage problems in the form of high ground-water tables. Deep percolation from additional irrigation on these lands, however, may contribute to the seepage of lower-laying lands. Thus occasional interceptor drains may be necessary. Protective drainage measures are also being considered in the Elberta and Mosida areas.

Provo Bay area is generally at or below compromise level of Utah Lake. Consequently, much of the land area is often inundated by the lake. Development plans include a dike to exclude lake water and a system of drains and a pumping plant to remove drainage water from the diked bay.

Topography[1]

The surface relief of the project lands is smooth to gently sloping. The relief is generally conducive to efficient irrigation without costly preparation of the lands. Smoothing in some areas would facilitate irrigation, but normally deep cuts would not be necessary. Irrigation erosion is not usually a problem on these smooth lands.

Climate[1]

The climate of Bonneville Basin is semi-arid. Deficiencies in rainfall are supplemented by the stored runoff of Wasatch mountain streams and from groundwater supplies developed in the basin alluvium. Precipitation is influenced by the orographic pattern and varies from less than 10 inches per year in the western portions of the Basin, to more than 40 inches in the higher zone of the Wasatch Range.

Transportation, Communications, and other Facilities

U. S. Transcontinental Highway 40 traverses most of the project area while U. S. Highways 50, 6, 89, and 91 serve the western part. Many bituminous-surfaced state and county highways link the area with the transcontinental routes. Several trucklines serve the area and the Union Pacific provides rail transportation to the western portion. The Salt Lake Municipal Airport furnishes facilities for air travel. A commercial airport is located at Provo, while smaller towns operate airports and landing strips for private air transportation.

The Mountain States Telephone and Telegraph Company supplies communication service; Utah Power and Light Company, electrical service; and Mountain Fuel Supply, gas service. Virtually all of the communities have grade schools and the larger ones have high schools. Utah University is located at Salt Lake City and Brigham Young University at Provo.

IV. THE ECONOMY

Resource Base

Of the major counties in the Central Utah Project area, Salt Lake and Utah Counties constitute the center of industrial and commercial activity in Utah. Kennecott Corporation has the largest industry in Salt Lake County with its open-pit mine at Bingham and its smelter at Magna-Garfield. U. S. Steel Corporation is the largest industry in Utah County. Iron ore is shipped to the steel mills for processing. Other important industries in the two counties are: steel products, lead and zinc mining, uranium ore processing, petroleum refining, fertilizer processing and manufacturing of construction and mining machinery and equipment. Agriculture requires fewer employees than either mining or primary metals. However, growing of irrigated crops, such as sugar beets, truck crops, canning crops and feed crops is practiced in the valleys wherever good quality land and water are available.

Lead and zinc are mined in Wasatch County and small sawmills are operated in Wasatch and Duchesne Counties. The Thermoid rubber products factory is located at Nephi, Juab County. These counties are primarily agriculturally oriented. Irrigation farming consists of raising feed crops for beef, dairy cattle and sheep. The Federal range furnishes part of the feed supply for beef cattle and sheep. Dry farm wheat is produced in Juab and Salt Lake counties. Employment in the mines at Eureka-Tintic in Juab county and the smelters at Tooele were not included in the Central Utah Project study area.

Employment in the extractive and manufacturing industries amounted to 23.9 percent of the total in 1960. Manufacture of durable goods comprised 9.9 percent; non-durable goods, 6.9 percent; mining 4.1 percent; and agriculture, 3.0 percent. Primary metals employed the most people in manufacturing followed by food and kindred products.

Service industries such as construction, transportation, communications, utilities, retail and wholesale trade, defense, public administration, and personal services aggregated 76.1 percent of employment in 1960. Personal services accounted for the largest number in the group. Recreation is one of the most important contributors to personal service employment in the study area because of many excellent skiing areas; boating on lakes and reservoirs; superb fishing in mountain streams, lakes, and reservoirs; outstanding hunting for deer, elk, and small game; outdoor camping, and all-round scenic mountain beauty.

Table 1 compares the relative importance of the Central Utah Project with the State of Utah in terms of employment in the major industrial categories. "Location Quotient" is the measure of importance. If its value is more than 1.0 then that industry is relatively more important in the Central Utah Project than the area with which it is being compared. Likewise, it is of less relative importance if the value is less than 1.0. In 1960, manufacturing and services were relatively more important in the study area than in Utah, while agriculture and mining were of lesser importance.

Table 2 compared the Central Utah Project with the United States. In 1960 it was relatively more important in mining and services compared with the United States and relatively less important in agriculture and manufacturing. However, the trend from 1940 to 1960 has been up in both phases of manufacturing, about stable in agriculture, erratic but up in mining, and down in services compared with the United States. Table 3 gives comparisons within the durable and non-durable industrial categories of manufacturing.

Present and Past Population

About 97 percent of the population in the Central Utah Project was located in the valleys and central trading centers of Salt Lake and Utah counties in 1960. Salt Lake and North Utah counties made the most rapid gain from 1940 to 1960, nearly doubling in population; 50 percent faster than Utah and three times as fast as the United States. South Utah county increased at about the same rate as the United States, while Juab, Wasatch, and Duchesne counties decreased in population. The Project area increased twice as fast as the United States and about 25 percent faster than Utah during the same period, Table 4.

Salt Lake City with a population of 189,454 in 1960 is the largest city, followed by Provo, 36,047. Populations of other larger cities are: Orem, 18,394; Kearns, 17,172; and Murray, 16,806. None of the towns in Juab, Wasatch and Duchesne counties had more than 3,000 population.

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TABLE 1 Comparison of the Relative Importance of Employment by Industrial Categories in the Central Utah Project Area with the Same Categories in Utah (Location Quotients) 1940, 1950, and 1960

	1940			1950			1960		
	% CUP ÷ % Utah =		Location Quotient	% CUP ÷ % Utah =		Location Quotient	% CUP ÷ % Utah =		Location Quotient
Agriculture, Forestry and Fishing	9.0	19.5	.46	6.0	12.6	.48	3.0	6.0	.50
Mining	7.2	6.8	1.06	4.6	5.3	.87	4.1	4.4	.93
Manufacturing	13.2	11.1	1.19	15.9	12.3	1.29	16.8	16.0	1.05
Durable	6.9	4.8	1.44	9.2	6.2	1.48	9.9	9.4	1.05
Non-Durable	6.3	6.3	1.00	6.7	6.1	1.10	6.9	6.6	1.05
Services and Other	70.6	62.6	1.13	73.5	69.8	1.05	76.1	73.6	1.03

TABLE 2 Comparison of the Relative Importance of Employment by Industrial Categories in the Central Utah Project Area with the same Categories in the United States (Location Quotients) 1940, 1950, and 1960

	1940			1950			1960		
	% CUP ÷ % U. S. =		Location Quotient	% CUP ÷ % U. S. =		Location Quotient	% CUP ÷ % U. S. =		Location Quotient
Agriculture, Forestry and Fishing	9.0	19.0	.47	6.0	12.5	.48	3.0	6.7	.45
Mining	7.2	2.0	3.60	4.6	1.6	2.88	4.1	1.0	4.10
Manufacturing	13.2	23.4	.56	15.9	25.4	.62	16.8	25.7	.65
Durable	6.9	11.2	.62	9.2	13.2	.70	9.9	13.8	.72
Non-Durable	6.3	12.2	.52	6.7	12.2	.55	6.9	11.9	.58
Services and Other	70.6	55.6	1.27	73.5	60.5	1.21	76.1	66.6	1.14

TABLE 3 Comparison of the Relative Importance of Employment in Manufacturing in the Central Utah Project Area and the United States (Location Quotient) 1940, 1950, and 1960

	1940			1950			1960		
	% CUP ÷	% U. S. =	Location Quotient	% CUP ÷	% U. S. =	Location Quotient	% CUP ÷	% U. S. =	Location Quotient
Manufacturing -- Durable	6.9	11.2	.62	9.2	13.2	.70	9.9	13.8	.72
Furniture, lumber and wood products	.6	2.0	.30	.6	2.1	.29	.6	1.7	.35
Primary Metals	3.8	1.9	2.00	6.1	2.1	2.90	4.8	1.9	2.53
Fabricated Metals	.8	1.4	.57	.6	1.4	.40	1.1	1.8	.61
Machinery except electrical	.4	1.5	.27	.7	2.2	.32	1.3	2.4	.54
Electrical Machinery Equipment and supplies	.1	.9	.11	.2	1.4	.14	.6	1.9	.32
Motor Vehicles and Motor Vehicle equipment	.1	1.3	.08	.1	1.5	.07	.1	1.3	.08
Transportation Equipment except motor vehicles	0	.5	0	0	0.5	0	.1	0.5	.20
Other Durable Goods	1.1	1.7	.65	.9	1.9	.47	1.3	2.1	.62
Manufacturing -- Non-Durable	6.3	12.2	.52	6.7	12.2	.55	6.9	11.9	.58
Food and Kindred Products	2.6	2.7	.96	2.4	2.6	.92	2.5	2.8	.89
Textile Mill Products	.4	2.6	.15	.2	2.2	.09	.2	1.5	.13
Apparel & Other Fabricated Textile Mill Products	.4	1.7	.24	.5	1.9	.26	.7	1.8	.39
Printing, Publishing and other allied products	1.7	1.4	1.21	1.8	1.5	1.20	1.6	1.8	.89
Chemical and allied products	.5	.9	.56	.5	1.1	.45	.8	1.3	.62
Other Non-Durable Goods	.7	2.9	.24	1.3	2.9	.45	1.1	2.7	.41

TABLE 4 - Population of the United States, Utah, and the Central Utah Project Area by Counties 1940, 1950, and 1960

Item	1940	1950	1960	Percent Inc.or Dec. 1940-60
United States	131,954,000	151,326,000	179,323,000	35.9
State of Utah	550,310	688,862	890,627	61.8
Salt Lake County	211,623	274,895	383,035	81.0
Total Utah County	57,382	81,912	106,991	86.5
North Utah County	29,579	50,037	71,113	140.4
South Utah County	27,803	31,875	35,878	29.0
Juab County(excl Eureka)	5,100	4,663	3,826	-25.0
Wasatch County	5,754	5,574	5,308	- 7.8
Duchesne County	8,958	8,134	7,179	-19.9
Central Utah Project	288,817	375,178	506,339	75.3
Percent Project of Utah	52.5	54.5	56.9	8.4
Percent Project of U. S.	.022	.025	.028	27.3

Future Growth

Employment and population projections with the Central Utah Project were made for 1985, 2010, and 2060. An unemployment rate of 4 percent of the labor force and an Armed Forces rate of 0.3 percent were assumed for the projection period. Total population was obtained by multiplying the labor force by 2.8 for the 1940, 1950, and 1960 ratio between population and labor force.

Employment in agriculture, forestry and fishing is expected to increase about 10 percent with construction of the Central Utah Project, initial and final phases. However, a decrease in farm numbers due to consolidation of small farms, greater efficiency in livestock and crop production, and residential development in Salt Lake and Utah counties will result in a net decrease in employment in agriculture by 1985. It is expected to continue at a less rapid rate of growth to 2010 and 2060, Table 5.

Mining employment is expected to increase in absolute numbers until 1985, but decrease in proportion to the total labor force. Columbia Iron Mining Company, Kennecott Copper Corporation, U. S. Mines, United Park City Mines Company, Vitro Corporation of America and Independent Coal and Coke Company, are expected to be the chief contributors. Considerable lead and zinc deposits have been located in the Eureka-Tintic area and

TABLE 5 Number Employed and Percent of Labor Force by Industries and Total Population Central Utah Project Area, 1960 and Projections for 1985, 2010, and 2060

Item	1960		1985		2010		2060	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Agriculture, Forestry and Fishing	5,268	2.9	4,000	1.2	3,100	.6	2,000	.2
Mining	7,175	3.9	8,600	2.5	8,600	1.6	8,600	1.0
Manufacturing								
Durable	17,467	9.6	31,400	9.3	46,700	8.7	69,900	8.0
Non-Durable	12,095	6.6	22,400	6.6	35,600	6.6	58,000	6.6
Total Extractive and Manufacturing	42,005	23.0	66,400	19.6	94,000	17.5	138,500	15.8
Service and Other 1/	133,914	73.2	257,100	76.1	419,900	78.2	697,900	79.9
Unemployed	6,418	3.5	13,500	4.0	21,500	4.0	35,000	4.0
Armed Forces	559	.3	1,000	.3	1,600	.3	2,600	.3
Total Labor Force	182,896	100.0	338,000	100.0	537,000	100.0	874,000	100.0
Not in Labor Force	323,443		600,000		955,000		1,555,000	
Total Population	506,339		938,000		1,492,000		2,429,000	
Ratio Total Population to Labor Force	2.8 to 1.0		2.8 to 1.0		2.8 to 1.0		2.8 to 1.0	

1/ Includes construction, defense, transportation, utilities, communications, distribution, finance, government, and other services

will have an indirect affect on the employment in mining. Increased demand for minerals after 1985 is expected to be offset by increased efficiency in mining and conveyance to processing mills, resulting in a stable labor force to 2010 and 2060. As in the past, mining has been more important in the Project area than in the United States and it is expected to continue until 2060.

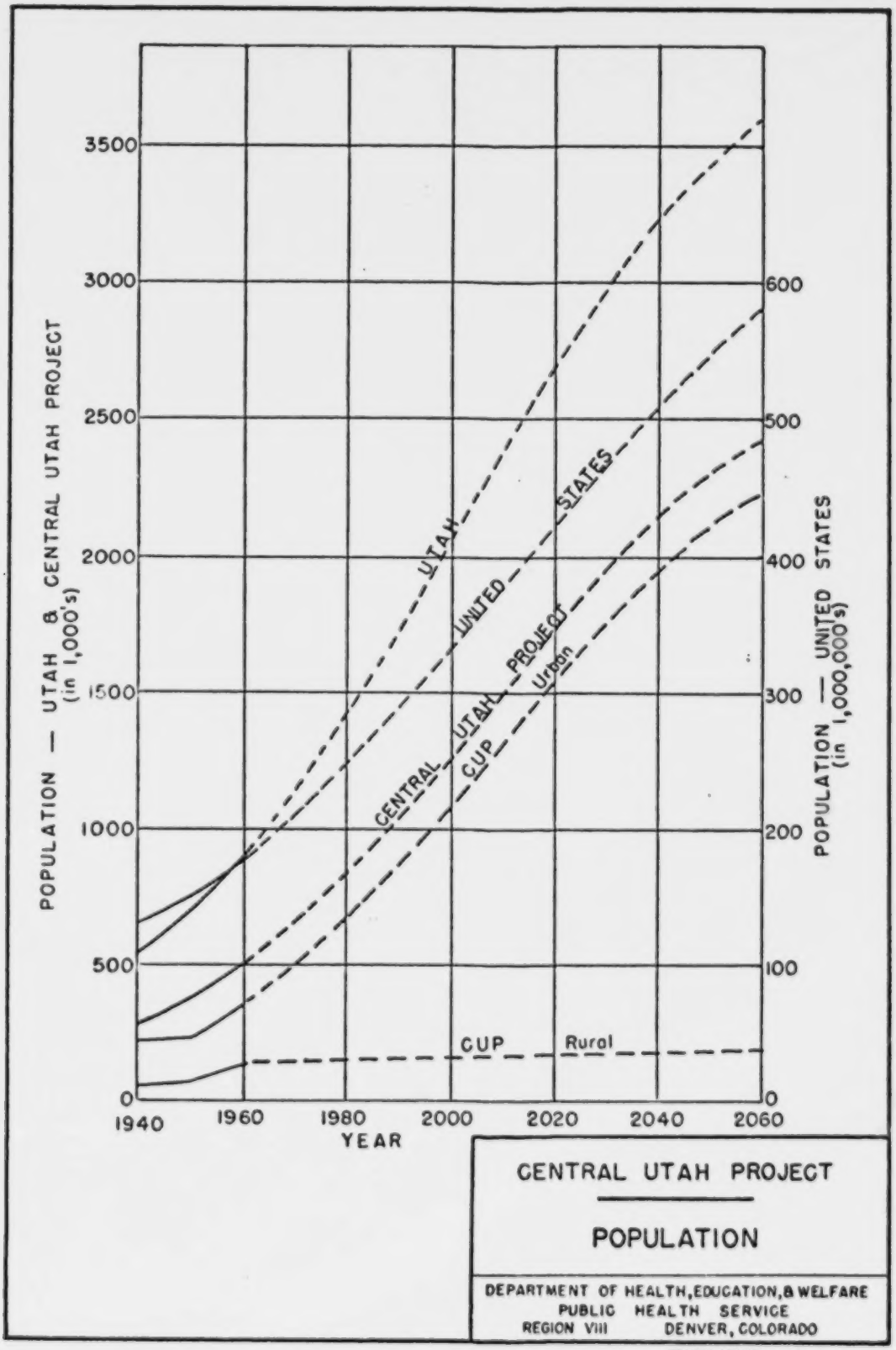
Durable goods are expected to more than hold their proportionate share of extractive and manufacturing employment. Their proportion of the labor force is expected to decrease from 9.6 percent in 1960 to 8.0 percent in 2060. However, the greatest absolute increase is expected in primary and fabricated metals; and in the manufacturing of construction, mining, and electrical machinery.

Most of the non-durable goods are population rather than resource oriented. Thus, employment in non-durables is expected to remain at about 6.6 percent of the labor force for the next 100 years. However, some proportionate increase is expected in apparel and other fabricated mill products, chemical and allied products, and rubber products. Food and kindred products and printing, publishing, and other allied products are expected to be proportionately stable. Textile mill products and other non-durable goods are expected to decrease in relative importance. From 1940 to 1960 both durable and non-durable goods gained in importance in the Project area when compared with the United States, Table 2.

Employment in the extractive and manufacturing industries are projected to decrease from 23.0 percent of the labor force in 1960 to 15.8 percent in 2060. This decrease is offset by a projected increase in services from 73.2 percent of the labor force in 1960 to79.9 percent in 2060.

An absolute increase of 50 percent in defense employment is expected in the next 10 years, then stable after that. Compound rates of growth used in projecting service employment from 1960 to 2060 are as follows: construction, 1.0 percent; transportation, communications, and utilities, 0.5 percent; distribution, 1.5 percent; finance, 2.0 percent; government, 2.0 percent; and other services, 2.0 percent.

After obtaining labor force projections and applying the 2.8 multiplier, population projections showed 938,000 for 1985, 1,492,000 for 2010, and 2,429,000 for 2060. The 2060 figure is 4.8 times larger than the 1960 population of 506,339, giving a compound rate of growth of 1-9/16 percent. This compares with a projected compound rate of growth of 1-7/16 percent for Utah and 1-1/8 percent for the United States, Figure 2.


POPULATION — UTAH & CENTRAL UTAH PROJECT (in 1,000's)
POPULATION — UNITED STATES (in 1,000,000's)
YEAR
3500
3000
2500
2000
1500
1000
500
0
600
500
400
300
200
100
0
1940
1960
1980
2000
2020
2040
2060
UTAH
UNITED STATES
CENTRAL UTAH PROJECT Urban
CUP
CUP Rural
CENTRAL UTAH PROJECT
POPULATION
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

17-A

FIGURE 2

V. WATER SUPPLY

Uses

Duchesne River and its tributaries, except Strawberry River, in 1960 provided 198,530 acre-feet of water for irrigation. In addition, 33,349 acre-feet were exported to the Provo River watershed.(4) The river is not used for municipal water supply. Strawberry River, a major tributary of the Duchesne, furnished 14,024 acre-feet for irrigation in 1960.

Provo River provides irrigation water to farmlands of the Provo River Water Users' Association near Lehi and American Fork, and West Jordan. About 13,000 acres near Heber also receive water from this river and its tributaries.

In 1960 about 28 percent of the municipal water supply of Salt Lake City was obtained from the Deer Creek Reservoir on Provo River. About 30 percent of the Provo municipal supply was obtained by exchange of Deer Creek water for spring waters.

Other water uses include the generation of hydroelectric power at Deer Creek Reservoir and Olmsted Plants, and cooling water at the Hale thermoelectric plant. From 4,000 to 8,000 gallons per minute (gpm) are drawn at Olmsted pumping station for cooling-water makeup at the Columbia-Geneva Steel Mills.

A substantial part of the Provo River flow is imported water from other basins. In the water year 1960 about 36,000 acre-feet were imported from the Weber River and 38,000 acre-feet from the Duchesne River and its tributaries.(5)

Utah Lake furnishes an estimated annual water supply of 180,000 acre-feet for irrigation, and 30,000 acre-feet for industrial purposes through the Jordan River. The greater part of the industrial water is used by the Kennecott Copper Corporation, and the Utah-Idaho Sugar Company.(6)

Marsh lands near the mouth of the Jordan River support a large population of migratory waterfowl. Numerous duck-hunting clubs are located there, as well as at the Farmington Bay Bird Refuge, a national wildfowl resting area.

Quality

Mineral

Provo River water is of acceptable mineral quality for domestic supply and irrigation. Duchesne River water is also acceptable above Tabiona, but downstream it is not desirable for culinary uses owing to irrigation return waters and other mineralized inflows. Concentrations of total dissolved salts and sulfates in the Duchesne River at Randlett exceed recommended maximums established for domestic water supplies.

Jordan River, an affluent of Great Salt Lake, is the natural outlet of Utah Lake. For about 60 years it has been a regulated stream. The draft upon Utah Lake for irrigation and industrial use lowers the lake level below the natural outlet during the irrigation season and all flow from Utah Lake is pumped. Only 2 percent of the water pumped from Utah Lake into the Jordan River remains in the river after diversions for irrigation and industrial uses at the Jordan Narrows.(3) Beyond the Narrows flow is partially restored by ground water, municipal and industrial waste waters, runoff of tributaries, and irrigation return flows. An excess of dissolved solids makes Jordan River water undesirable for domestic water supply.

Mineral content of the Provo, Duchesne, and Jordan Rivers is shown in Table 6. Mineral content of Utah Lake water is governed by an interplay of inflow, evaporation and withdrawals from the lake, and also by seasonal precipitation of calcium and magnesium carbonates. For the critical drouth period, 1929 to 1936, chloride concentrations were calculated to have ranged from about 220 parts per million (ppm) to 1580 ppm, corresponding to concentrations 880 to 6320 ppm of total dissolved salts. However, during the 1921-60 period chloride concentrations ranged from about 106 to 1880 ppm, corresponding to total dissolved solids concentrations of 441 ppm to 6130 ppm.1/

1/ Bureau of Reclamation, 2/19/63

TABLE 6

Mineral Analyses of Streams

Source and Location	Sample Date	EC x10^6	pH	TDS ppm	Parts per Million (ppm) Ca	Mg	Na	K	Fe	HCO_3	Cl	SO_4
PROVO RIVER 1/ below Deer Creek Res.	4/4/61	414	8.3	271	46	17	15	3	--	123	13	88
	8/7/61	429	8.4	280	56	14	12	3	--	158	11	64
	11/3/61	490	8.2	303	77	12	15	3	--	180	14	96
	2/7/62	415	8.4	278	42	16	15	4	--	121	12	83
DUCHESNE 2/ RIVER near Randlett	1957 Water Year	961	6.9 to 8.1	646	72	34	96	2	--	222	48	269
JORDAN RIVER 3/ near Lake Pumping Sta. Mile 54.5	1957	---	--	1106	52	83	200	24	2	259	259	330
JORDAN RIVER 3/ at 106th So th St. Mile 34.3	1957	---	--	1882	166	137	260	29	1	333	436	651
JORDAN RIVER 3/ at 21st South St. Mile 18.2	1957	---	--	1223	105	94	172	15	5	250	251	443

1/ Data from files of Region 4, U. S. Bureau of Relcamation
2/ Flow-weighted means, from USGS WSP No. 1523
3/ Flow-weighted means, samples collected March to December 1957 for the Utah State Water Pollution Control Board

Sanitary

In the first 20 miles of the Jordan River the sanitary quality is satisfactory. Biochemical oxygen demand (BOD) averages 2.5 ppm at Draper-Riverton Road, Mile 36.8. Most Probable Number (MPN) of coliform bacteria averages 3,100 per 100 milliters (ml) at Bluffdale. Below Riverton the sanitary quality is degraded by inflow of sewage and industrial wastes.

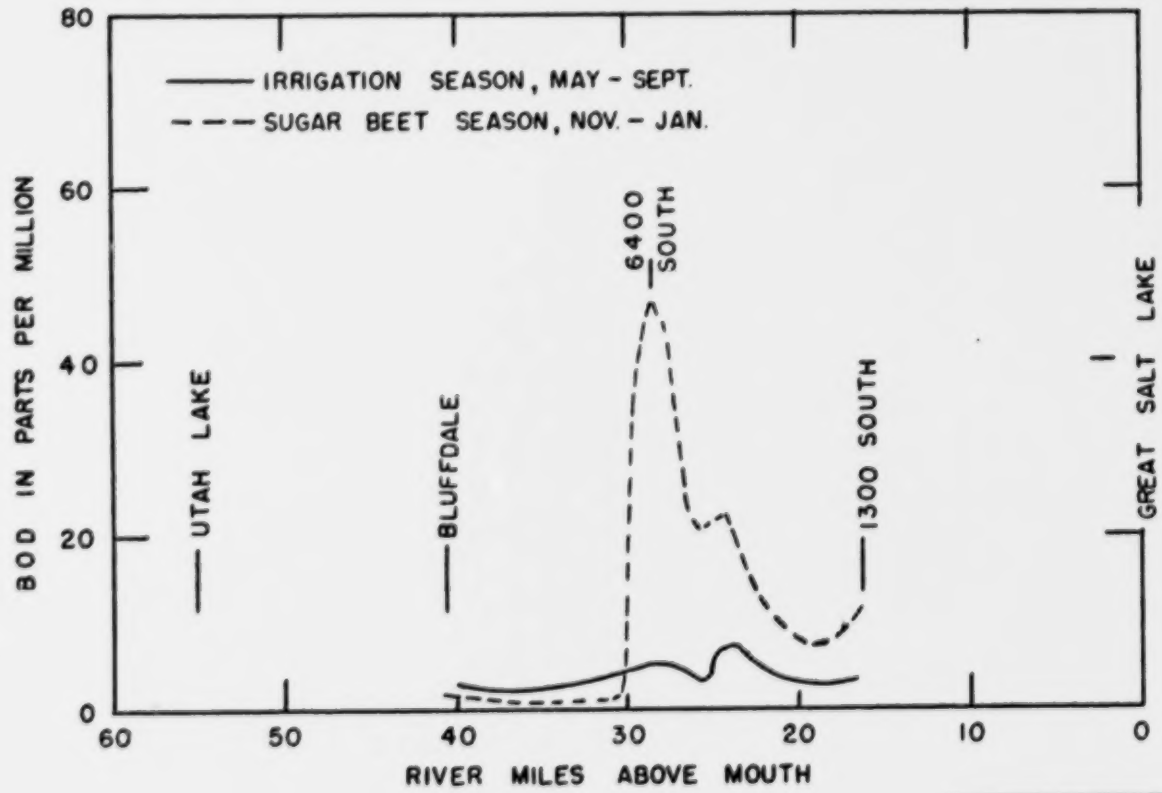
Efforts of the Utah State Water Pollution Control Board have secured a high degree of treatment for municipal wastes discharged into Jordan River. All sewered communities practice both primary and secondary sewage treatment. An additional requirement of post-chlorination of sewage effluents was requested December 28, 1962 by the State Board. With respect to industrial waste discharges, the situation is less satisfactory. A large beet sugar plant at West Jordan, River Mile 30, raises BOD's in the river more than tenfold during its seasonal operation, November to January.

The progressive changes downstream in sanitary quality of Jordan River, as measured by BOD, are illustrated in Figure 3.

State Standards

Quality standards and a system of water classifications were adopted by the Utah Water Pollution Control Board November 19, 1954 and amended September 7, 1960. Five classes of waters are recognized, ranging downward from "A," suitable for all beneficial uses without treatment, to "E" in which the only concern is prevention of nuisances. A special category designated by the subscript figure one is used to acknowledge pollution from natural causes, in excess of limits denoted by the alphabetical letter.

The State Standards,[15] including numerous parameters of quality, are illustrated by the requirements for Class "C" waters, shown in Appendix "B." No stream or lake in the Project area has yet been classified. However, the Utah Water Pollution Control Board has under consideration the classification of the Jordan River as "C_1."



CENTRAL UTAH PROJECT

BOD PROFILE
JORDAN RIVER

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

DATA FROM: UTAH WPC BOARD — 1960-62

FIGURE 3

H-12

Effects of Project Operation

The Duchesne segment is an integral part of the Colorado River Basin now under study by the Colorado River Basin Water Quality Control Project, Public Health Service, Denver, Colorado. One of the objectives of this basinwide effort is to develop a plan for long range comprehensive water quality management. Since a study of the Duchesne segment is being made in advance of the comprehensive study, certain materials and preliminary recommendations presented must necessarily await later confirmation.

The Uinta Basin water which will be exchanged directly for Provo River water in Utah Lake is similar in mineral content, and hence the qualitative effect of the exchange on Utah Lake would be negligible. The chief factors affecting mineral quality of the lake water will be the diking of Provo Bay and Goshen Bay, and the planned exclusion from the lake of irrigation return flows from the Mosida area.

The Bureau of Reclamation estimates that diking of Goshen Bay and Provo Bay will result in a net reduction in evaporation losses from Utah Lake of about 80,000 acre-feet of water annually. In addition, the Goshen Bay dike will exclude an estimated inflow of about 30,000 acre-feet annually of highly mineralized waters.

Peak concentrations of dissolved salts in Utah Lake would be reduced under project operating conditions. The calculated mean concentration of chlorides for the critical period 1929-36 would be reduced from 439 ppm to 227 ppm, or 48 percent. Calculated mineral quality with and without the Central Utah Project is shown graphically in Appendix "A," Figure A. However, based on the 1921-60 period the mean concentration of chlorides would be reduced from 212 ppm to 147 ppm, or 31 percent.

Inflow to Mona Reservoir will be increased by greater volumes of irrigation return flows and by direct transmountain diversions from Strawberry Reservoir during the winter months. Under project operations the peak concentrations of dissolved solids would be reduced. The seven-year mean is reduced from 980 ppm to 630 ppm, or 36 percent. Qualitative effects are shown in Appendix "A," Figure B.

Mineral quality of Deer Creek Reservoir and Provo River water is expected to remain essentially unchanged. The main result of the project development on this stream will be to intercept, store, and make available for urban use a greater proportion of the existing flow. The general quality of Provo River water was shown in Table 6.

Quality of water in Strawberry Reservoir, averaging 0.2 to 0.3 tons per acre-foot (TAF) (150 to 220 ppm) of dissolved solids throughout the year, will be practically unchanged by the project. Releases from this reservoir to Spanish Fork River will improve the quality of that stream during the winter months, but leave it virtually unchanged during the irrigation season as shown in Table 7.

TABLE 7

SPANISH FORK RIVER AT CASTILLA
Estimated Total Dissolved Solids (14)
(Tons per Acre-Foot)

Month	Historical 1954-1960	With Project	Month	Historical 1954-1960	With Project
November	0.5-0.7	0.4	May	0.2-0.3	0.2-0.3
December	0.5-0.7	0.4	June	0.3	0.3
January	0.5-0.6	0.4	July	0.3	0.3
February	0.5-0.6	0.4	August	0.3	0.3
March	0.4-0.5	0.4	September	0.4-0.5	0.3-0.4
April	0.3-0.5	0.3-0.4	October	0.4-0.6	0.4

Diversions from the Duchesne River to the Starvation Reservoir on Strawberry River will not alter Duchesne River quality above the diversion dam. However, salts concentration in the Duchesne River below the confluence with the Strawberry River and at the Myton Townsite Canal would be increased as shown in Table 8. The Bureau of Reclamation has indicated that the need for additional water in the Duchesne River for water quality maintenance will receive additional study under project operations.

TABLE 8

Duchesne River
Estimated Total Dissolved Solids[14]
(tons per acre-foot)

Month	Below Strawberry Confluence		At Myton Townsite Canal	
	Historical 1946-1960	With Project	Historical 1952-54 and 1959-60	With Project
November	0.4-0.5	0.5	1.0	No
December	0.4-0.5			
January	0.4-0.6	to	to	Project
February	0.5			
March	0.5	1.0	2.0	Water
April	0.3-0.5			
May	0.2-0.4	0.4-1.0	0.3-1.2	0.5-2.0
June	0.2-0.4	0.2-0.8	0.2-1.2	0.3-1.2
July	0.3-0.5	0.3-0.6	0.4-1.5	1.1-1.3
August	0.4-0.6	0.3-0.6	0.5-1.3	0.9-1.3
September	0.4-0.7	0.4-0.7	0.5-1.3	1.0-1.2
October	0.4-0.6	0.6-0.8	0.8-2.5	1.0-2.0

Municipal Supply

The plan of development for Provo River contemplates increasing supplies of municipal water to Salt Lake City and northern Utah County areas. Quality of Provo River water therefore was compared with other sources of supply for Salt Lake City to ascertain whether or not benefits would be conferred by increasing the proportion of the total supply from the Provo River. Table 9 shows data for Salt Lake City water supplies.

TABLE 9

Salt Lake City
Sources and Quality of Water Supply, 1957[7]

Source	Average Million Gallons per Day	Percent of Total Supply	Parts per Million				
			TDS	Hardness	Cl	SO_4	Fe
Provo River-Deer Creek Reservoir	21.0	36	270	213	10	58	.04
Big Cottonwood Creek	6.7	12	162	139	4	38	.04
Little Cottonwood Creek	9.5	16	101	75	2	30	.14
Parley's Creek	6.6	11	309	233	20	33	.02
City Creek	3.2	5.5	252	224	16	17	.05
Deep Wells (pumped)	8.4	14	471	334	41	99	.05
Artesian Wells & Springs (composite samples)	3.2	5.5	308	208	28	63	.03

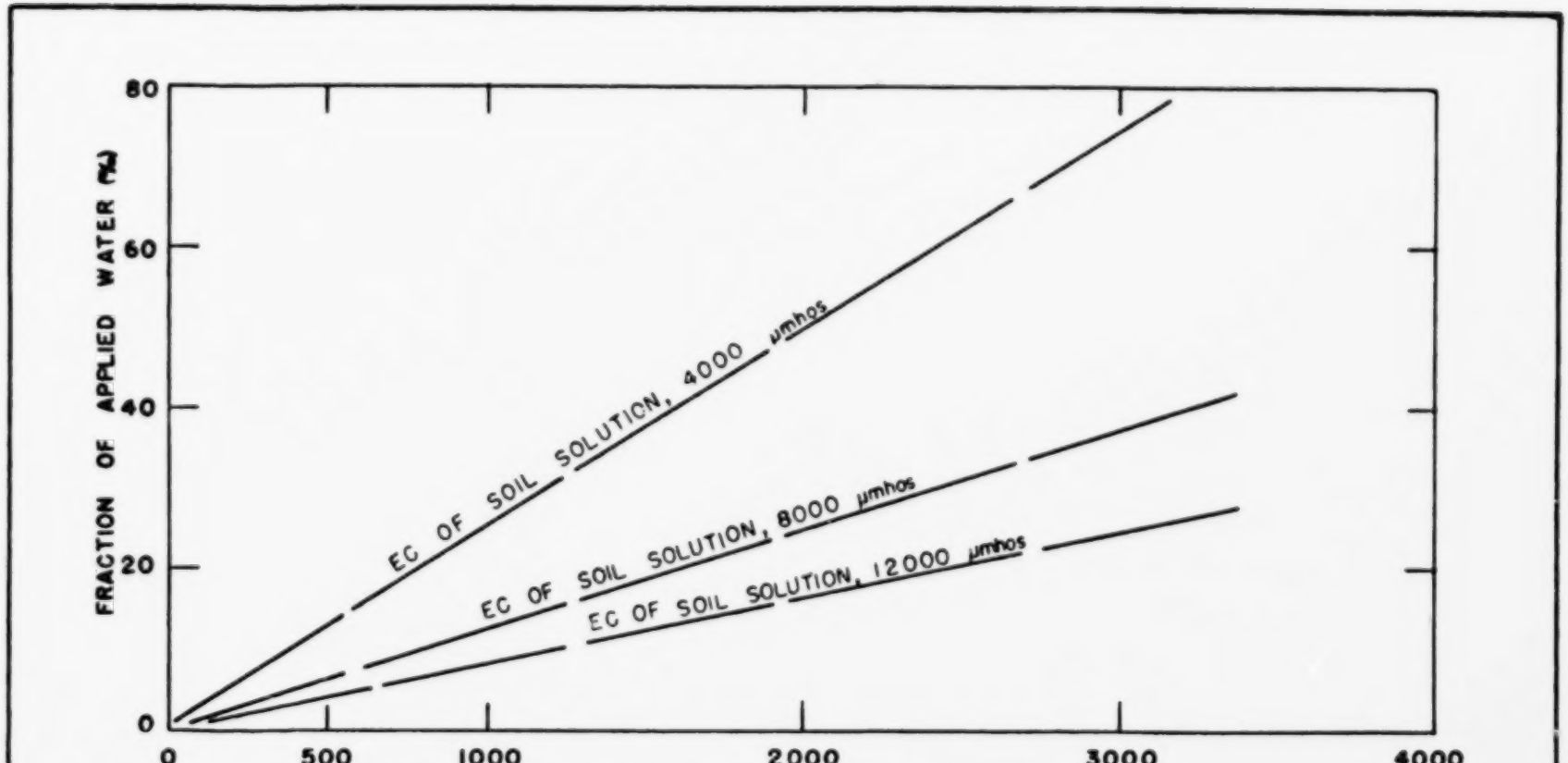
From the table above it is apparent that the Provo River supply is inferior in most respects to the two Cottonwood creeks; about the same as the other surface sources, artesian wells and springs; and considerably better than the deep well sources.

Industrial Supply

Nearly 30,000 acre-feet of water are drawn annually for industrial uses from Utah Lake through Jordan River and its canals. Kennecott Copper Corporation diverted nearly 27,000 acre-feet in 1961 for concentration and extraction of copper ores near Magna, Utah-Idaho Sugar Company drew about 2,200 acre-feet for fluming beets in its West Jordan plant. (The latter firm purchases additional water, of better quality from the Salt Lake County Water Conservancy District.)

Fish and Aquatic Life

Excessive concentration of dissolved mineral solids is known to be harmful to fresh water fishes. A specific conductance between 1,000 and 2,000 micromhos is the maximum permissible for streams to support fish and aquatic life in western alkaline areas.[9] The Central Utah Project is expected to reduce the mineral content of Utah Lake and upper Jordan River.



FROM: U. S. Dept. of Agriculture – Handbook No. 60

CENTRAL UTAH PROJECT

LEACHING WATER REQUIREMENTS

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

FIGURE 4

Irrigation

The chief use of Utah Lake water at present is for irrigation. The value of better mineral quality resulting from project operation can be calculated. The mineral salts left in a soil solution by plant transpiration must be removed by leaching to prevent a build-up to harmful concentrations. In humid climates the necessary leaching is accomplished by natural precipitation percolating through the root zone. In semi-arid regions, rainfall must be supplemented by applying water in excess of irrigation requirements. The theoretical amount of water required to maintain equilibrium salt concentration in the soil solution is a function of the mineral content of the applied water. Figure 4, prepared from information in Agriculture Handbook No. 60, shows the relationship between leaching water requirements and the electrical conductivity of applied water.(10)

The 31 percent reduction in average chloride concentration in Utah Lake, under project operations, corresponds to a reduction in total dissolved solids from 855 ppm to 588 ppm and a reduction in specific conductance from 1300 to 920 micromhos.[1/] This reduction in average chloride concentrations reflects annual averages for the period, 1921-60, without and with the project. The potential annual saving in leaching water requirement, for a soil solution of 8,000 micromhos, was calculated as follows:

	Proportion	Leaching Water, Acre-Feet
Without Central Utah Project	0.17)	30,600
With Central Utah Project	0.11) x 180,000 a.f.	19,800
Annual Saving Acre-Feet (without conveyance loss)		10,800
(with 30% conveyance loss)		7,560

1/ Bureau of Reclamation, 2/19/63

Future Municipal and Industrial Water Requirements

The Public Health Service was not requested to make a specific study of municipal and/or industrial water supply requirements. However, employment in the labor force, by industries, was projected for 1985, 2010, and 2060 to estimate probable volume of industrial wastes. Municipal water requirements were based upon projected population for the same periods to arrive at the volume of municipal wastes.

The Bureau of Reclamation contracted with the Bureau of Economic and Business Research, University of Utah, for projection of municipal and industrial water requirements for all Utah counties. The final results of that study for the major counties of the Central Utah Project were not available for the present Public Health Service study. If significant differences occur in the two reports, some adjustment may be deemed necessary.

VI. MINIMUM FLOW REQUIREMENTS

Under provisions of the Federal Water Pollution Control Act, Public Law 84-660, as amended by Public Law 87-88, in the survey or planning of a reservoir by any Federal agency, consideration must be given to the inclusion of storage for regulation of streamflow for the purpose of water quality control. It is expressly stated that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling wastes at their sources.

Discharge of wastes, even when treated to the maximum economically feasible and practical limit, will cause an unsatisfactory quality condition in receiving waters whose waste assimilation capacity is exceeded. This condition generally occurs during periods of low flows and may be avoided by the addition of water to maintain flows at higher levels. It is essential that recognition be given to the need for flows which must prevail in receiving streams if the quality of their waters is to be maintained at acceptable levels.

Stream Quality Maintenance

The following criteria and/or conditions were used for estimating water quality control requirements:

1. That waste treatment facilities will remove 85 percent of the organic substances exerting a biochemical oxygen demand (BOD).

2. The effluent from waste treatment facilities will be uniformly mixed in the receiving stream.

3. The dissolved oxygen (DO) content, corrected for temperature and altitude, in the surface waters will be:

    a. 5 ppm or greater for Duchesne, Provo, and Spanish Fork Rivers, and Mona Reservoir for protection of habitat for game fish; and

    b. 4 ppm or greater for Utah Lake and Jordan River for protection of habitat for rough fish and general recreational use.

4. Stream self-purification coefficients were chosen by analogy and judgement.(11)

5. With total dissolved solids (TDS) of 1000 ppm being acceptable, chemical and physical characteristics of surface waters will not exceed limits as described in the Public Health Service Drinking Water Standards in areas of potential municipal water needs.

6. Storage and/or regulated releases of industrial wastes will accomplish optimum use of the surface water resources.

Duchesne River

Table 10 shows existing wastewater discharges, based on estimated population equivalents, into Duchesne River and its primary tributaries.

TABLE 10

Wastewater Discharges to Duchesne River(12)

Community	Sewered Population	Sewage Treatment	Estimated Population Equivalent of Effluent
Duchesne	700	Imhoff Tank	700
Fort Duchesne	200	Septic Tank, Oxidation Pond	(Zero except for overflows)
Myton	100	None	100
Roosevelt	1800	Imhoff Tank	2300
TOTALS	2800		3100

During the 18-year period of record ending in September 1960, the average flow at Randlett was 594 cfs. The absolute minimum was 8.4 cfs, occurring August 22, 1960. July, August, and September are normally the driest months.(13) Table 11 shows the calculated minimum flows necessary to meet stream quality requirements in the Duchesne River below Roosevelt.

TABLE 11

Calculated Minimum Flows to meet Stream Quality Requirements, Duchesne River below Roosevelt, Utah

Condition	Waste Discharge Population Equivalent	BOD lbs/day	Flow (cfs) Available	Flow (cfs) Required
Present	3100	775	8.4 1/	10.2
Present modified for 85% BOD removal	465	116	8.4	1.5
1985 modified	703	176	8.4	2.3
2010 modified	952	238	8.4	3.1
2060 modified	1380	345	8.4	4.5

1/ Minimum daily historical

Utah Lake

Tables 12 and 13 show present organic waste loadings of Utah Lake from municipal and industrial sources. The estimated population equivalent of wastes from all sources is about 126,000, of which 84 percent is of industrial origin.

Table 14 shows computed historical inflows to Utah Lake, without and with the Central Utah Project, for the period 1921-60.

TABLE 12

Municipal Wastewater Discharges to Utah Lake and Tributaries (12)

Community	Sewered Population	Sewage Treatment	Estimated Population Equivalent
American Fork	6,900	Trickling Filter Chlorination	1,035
American Fork State Training School	1,000	Clarifier Trickling Filter	100
Heber	2,490	High Rate Trickling Filters, Chlorination	375
Lehi	4,000	High Rate Trickling Filters, Chlorination	600
Orem	18,000	High Rate Trickling Filters, Chlorination	2,760
Payson	2,500	Imhoff Tank	2,500
Pleasant Grove	4,000	High Rate Trickling Filter, Chlorination	600
Provo	40,000	High Rate Trickling Filter, Chlorination	8,000
Spanish Fork	5,500	High Rate Trickling Filter, Chlorination	2,670
Springville	7,913	Trickling Filter Chlorination	1,200
Totals	92,390		19,840

TABLE 13

Industrial Wastewater Discharges to Utah Lake and Tributaries (12)

Plant	Treatment	Population Equivalent of Wastes
Lehi		
Lehi Roller Mills	None	---
Geneva		
Geneva Steel	Settling Tanks	490
Consolidated Western Steel Company	Trickling Filters	48
Orem		
Pleasant Grove Canning Company 1/	Fine Screen	31,500
Pleasant Grove		
Pleasant Grove Canning Company 1/	None	8,000
Provo		
Geneva Steel (Ironton Plant)	Settling Ponds	200
John Kuhni & Sons	None	600
Pacific States Cast Iron Pipe Company	None	---
Republic Creosote	None	---
Utah County Packing Company	None	500
Spanish Fork		
California Packing Company 1/	Screens	51,000
Utah Hide & Tallow Company	Lagoon	---
Utah County		
Eddington Cannery and Other Packing Plants	None	14,400
	TOTAL	106,738

1/ Seasonal waste discharge

Table 14
Inflow to Utah Lake
Without and With Central Utah Project 1921-60

	Without Project Conditions					With Project Conditions							
Month	Average Monthly* Inflow without Project[1] 1,000 Acre-feet	cfs	Number of Years with Inflow Below 197 cfs[3]	Evaporation* Acre-feet	Yield* from Utah Lake 1,000 Acre-feet	Average* Monthly Inflow without Project 1,000[1] Acre-feet	Effect* of the Central Utah Project on Inflow 1,000 Acre-feet	Average* Monthly Inflow under the Central Utah Project[2] 1,000 Acre-feet	cfs	Number of Years with Inflow Below 197 cfs[3]	Evaporation* 1,000 Acre-feet	Effect* of the Central Utah Project on Evaporation 1,000 Acre-feet	Yield* from Utah Lake 1,000 Acre-feet
1	2	3	4	5	6	7	8	9	10	11	12	13	14
October	38.9	633	1	19.2	10.4	38.9	- 6.6	32.3	525	1	11.6	- 7.6	12.1
November	44.7	751	0	7.4	2.2	44.7	-12.3	32.4	545	1	4.4	- 3.0	2.2
December	51.8	842	0	2.8	0	51.8	-14.0	37.8	615	1	1.8	- 1.0	0
January	52.5	854	0	2.5	0	52.5	-10.2	42.3	688	0	1.6	- .9	0
February	57.0	1026	0	3.5	2.2	57.0	- 6.8	50.2	904	0	2.3	- 1.2	2.2
March	67.5	1098	0	16.4	2.2	67.5	- 7.5	60.0	976	0	10.2	- 6.2	2.2
April	70.6	1187	0	32.8	8.8	70.6	- 4.7	65.9	1108	0	20.4	-12.4	10.4
May	68.3	1111	1	47.8	35.2	68.3	- 1.0	67.3	1094	0	29.6	-18.2	44.5
June	52.7	886	1	56.3	48.4	52.7	- 1.3	51.4	864	0	33.4	-22.9	61.0
July	28.3	460	3	58.3	51.6	28.3	+ 4.0	32.3	525	2	35.8	-22.5	65.8
August	27.0	439	4	48.4	33.5	27.0	+ 4.8	31.8	534	2	29.5	-18.9	42.7
September	22.8	383	4	34.2	20.9	22.8	+ 3.0	25.8	420	2	20.8	-13.4	25.6
Total	582.1			329.6	215.4	582.1	-52.6	529.5			201.4	-128.2	268.7

* Data from Bureau of Reclamation

1/ Computed future modified inflow to Utah Lake from all sources without the Central Utah project but with the Provo River project in full development

2/ Computed future modified inflow to Utah Lake from all sources under Central Utah project conditions; taken from "Utah Lake Operation Study B."

3/ Computed minimum inflow required for present water quality maintainance from Table 15.

TABLE 15

Calculated Minimum Inflow to Utah Lake to meet Water Quality Requirements with Seasonal Industrial Wastes Included and Excluded

Condition	Waste Discharge Population Equivalent		BOD Lbs/Day		Required Flow, cfs	
	Included	Excluded	Included	Excluded	Included	Excluded
Present 1/	126,600	20,500	31,650	5,125	840	136
Present modified with 85% BOD removed	29,800	14,000	7,450	3,500	197	93
1985 modified	54,000	25,400	13,500	6,350	357	169
2010 modified	84,000	39,500	21,000	9,875	555	263
2060 modified	133,000	62,700	33,250	15,700	876	416

1/ Waste treatment as shown in Tables 12 and 13

With seasonal industrial wastes included the project inflows are sufficient for present and 1985 under all but extreme drouth conditions. By 2010 the inflow requirements would rise to 555 cfs, and in 2060, to 876 cfs.

It may, however, prove practicable to reduce these requirements by excluding entirely from the lake seasonal industrial wastewater discharges. This might be accomplished by some form of final disposal on land. Seasonal food-processing wastes, (106,000 P.E.), comprise about 84 percent of the total waste production at present, and the effect of keeping these wastes out of Utah Lake is shown in Table 15.

Based on the required flows shown in the preceding table, with seasonal industrial wastes removed, in only 3 of the 480 months (1921-60), would there be inadequate inflow to Utah Lake, without the project, to meet water quality requirements at the present modified conditions. With the project there would be no exceptions. By 1985 there would be 11 exceptions without the project, and 6 exceptions with the project. Exceptions for the years 2010 and 2060 would be greater.

The number of months during the critical 72-month period, 1931-36, that historical inflows to Utah Lake would have been below the computed flow required for water quality control are summarized as follows:

With industrial wastes included --

Year	Number Months Without Project	With Project
1960 modified	9	3
1985	22	20
2010)	Number of months below required flows greater	
2060)	than number of months above required flows	

With season industrial wastes excluded --

1960	1	0
1985	7	3
2010	15	13
2060	27	29

Jordan River at 2100 South, Salt Lake City

Table 16 shows present discharges of sewage and industrial wastes to Jordan River. The population equivalent of treated wastes entering the stream is about 120,000, of which 93,000 is a seasonal flow from a single food-processing plant. The computed streamflows required for water quality control are shown in Table 17.

TABLE 16

Municipal and Industrial Wastewater
Discharges to Jordan River (12)

Community or Establishment	Miles Above Mouth	Population	Treatment	Estimated Population Equivalent
Utah State Prison 1/	39.5	600	Activated Sludge	75
Sandy City Improvement District	31.0	3,000	Activated Sludge	300
Utah-Idaho Sugar Company 2/ West Jordan	30.2	---	Screen and Settling	93,000
U. S. Smelting and Refining Company	29.9	---	Ponding	---
Midvale	29.0	5,802	Trickling Filter	1,300
Kearns Improvement District	26.0	17,172	Trickling Filter	2,570
Murray	24.6	13,513	Trickling Filter	1,350
Granger-Hunter Improvement District	21.0	12,000	Trickling Filter	1,800
Salt Lake County - Cotton Sanitation District	21.0	9,000	Trickling Filter	1,350
Vitro Uranium Company	20.3	---	Tailings Pond	---
Salt Lake City Sanitation District No. 1	20.0	65,000	Trickling Filter	13,000
South Salt Lake	18.0	19,520	Trickling Filter	5,200
			TOTAL	119,945

1/ Includes Seasonal Canning
2/ November to January

TABLE 17

Calculated Minimum Flow Requirements for Water Quality Control
Jordan River at 2100 South, Salt Lake City
with Seasonal Industrial Wastes Included and Excluded

Condition	Waste Discharge Population Equivalent		BOD Lbs/Day		Required Flow, cfs	
	Included	Excluded	Included	Excluded	Included	Excluded
Present 1/	120,000	27,000	30,000	6,750	244	55
Present modified	36,800	22,800	9,200	5,700	75	46
1985 modified	70,000	43,000	17,375	10,750	141	87
2010 modified	112,000	69,000	27,900	17,250	227	140
2060 modified	184,000	113,000	46,000	28,250	374	230

1/ Waste treatment as shown in Table 16

Based upon historical streamflow requirements, the average monthly flows would be sufficient to meet water quality requirements until about 2010 with seasonal industrial wastes included. However, with seasonal industrial wastes excluded, streamflow would be adequate through 2060. Average and individual monthly historical flows would meet water quality requirements (374 cfs) about 20 percent of the time by the year 2060, with industrial waste loads included. Ninety-three percent of the time, 1943-61, minimum historical flow exceeded 200 cfs and only 2 percent of the time fell below 150 cfs. Table 18 summarizes historical flow data at 2100 South, Salt Lake City, Utah, 1943-61.

TABLE 18

Historical Flows in Jordan River at 2100 South
Salt Lake City, Utah, 1943-61

Month	Average Monthly Flow 1/ (1000 a.f.)	(cfs)	Number of Years by Months Below 2/ 75 cfs	141 cfs	227 cfs	374 cfs
October	19.5	317	0	0	0	17
November	17.0	285	0	0	1	17
December	17.6	287	0	0	5	17
January	17.3	281	0	0	13	16
February	17.0	302	0	0	10	16
March	20.1	327	0	0	7	15
April	20.4	342	0	0	6	14
May	25.3	412	0	0	1	10
June	27.0	453	0	1	1	7
July	18.0	293	0	1	1	18
August	17.4	283	0	1	3	18
September	18.6	313	0	0	1	17

1/ USGS Water Supply Papers, Surface Water Supply of the Great Basin (1943-61)

2/ Required flows shown in Table 17 with seasona industrial waste included

VII. ECONOMIC BENEFITS

Economic benefits were computed on the basis of values added by improvement in water supply for water quality control. Historical data, modified to meet without and with Central Utah Project conditions, were projected into the future. The physical quantities and qualities of water available and the amount required with the economic growth contemplated accounted for the difference on which benefits were estimated. The Bureau of Reclamation calculated direct benefits for irrigation at $30.00 per acre-foot in the Bonneville Unit, Central Utah Project. This figure was applied as a measure of the minimum benefits attributable to water for regulation of streamflow for the purpose of water quality control. Insofar as Provo River water could be exchanged for deep well water supplies serving Salt Lake City, benefits would accrue through improved quality due to savings in soap, detergents, and general household cleansers from the reduction of hardness. The computed annual gross benefit was based on $1.15 per capita per 100 ppm reduction in hardness.(8)

Benefits were discounted to present values and it was assumed that the Central Utah Project, Initial Phase, would be in operation by 1970. Benefits from water quality improvements in Spanish Fork River were not computed because of insufficient data. However, water quality in the Duchesne River would be adversely affected due to transmountain diversion of part of its present supply. These negative benefits are not determinable at this time due to insufficient data.

The Duchesne Unit is an integral part of the Colorado River Basin now under study by the Colorado River Basin Water Quality Control Project, Public Health Service, Denver, Colorado. One of the objectives of this basinwide effort is to develop a plan for long range comprehensive water quality management. Since this study of the Duchesne Unit is being made in advance of the comprehensive study, certain materials and preliminary recommendations presented must necessarily await later confirmation.

Locations and conditions under which annual benefits provided by development of the Central Utah Project and additional benefits, if computed streamflow regulation is provided, for the purpose of water quality control are as follows:

a. Benefits attributable to organic quality improvement with removal of 85% of the BOD.

Location	Automatic Benefits with Project Development	Additional Benefits if Computed Streamflow Regulation is Provided	Total Benefits
Utah Lake	$ 15,180	$ 342,270	$ 357,450
Jordan River (at 2100 So.-SLC)	None	$ 74,700	$ 74,700
Subtotal	$ 15,180	$ 416,970	$ 432,150

b. Benefits attributable to chemical quality improvement.

Utah Lake (irrigation water savings)	$170,820	None	$ 170,820
Salt Lake City (exchange deep wells supply for Provo River)	$ 39,200	None	$ 39,200
Subtotal	$210,020	None	$ 210,020
TOTALS	$225,200	$ 416,970	$ 642,170

All the above described benefits are considered to be widespread in scope with the exception of exchange water for Salt Lake City. The widespread automatic benefits would total $186,000 annually while widespread additional benefits, if computed streamflow regulation is provided, would amount to $416,970 annually for a combined total of $602,970.

If Provo River water could be exchanged for deep well water serving Salt Lake City then gross savings of $39,200 annually could be expected due to reduction in hardness. However, the present deep well water supply is used near the source for culinary purposes, thus exchange benefits would be local in scope. Data were not available to compare the cost of operation, maintenance, and replacement for the deep well water supply with that of the Provo River supply.

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PART B - PUBLIC HEALTH ASPECTS

I. SUMMARY AND RECOMMENDATIONS

Summary

Mosquitoes are the principal vectors which might be affected by the project. Several species of mosquitoes having a public health significance may be produced in large numbers in the general project area when suitable aquatic habitats are present. Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the project area. During 13 years of the 17-year period, 1939-1955, equine encephalitis cases occurred in Utah County. During 4 of these years Utah County had an incidence in excess of 5 encephalitis cases per 1,000 horses. During 5 years of the 12-year period Duchesne County reported equine encephalitis cases, and in 2 of these years had an incidence in excess of 5 cases per 1,000 horses.

The most recent epidemic of encephalitis occurred in Utah during the late summer and fall of 1958. This epidemic, centered in an area about 75 miles north of Utah County, involved 48 laboratory-confirmed human cases and was the largest outbreak of this disease among humans in the history of the State.

The production of mosquitoes and other aquatic insects of public health significance is widespread in many irrigation areas. Man-made mosquito breeding areas are frequently caused by the same faulty irrigation and drainage practices that cause serious soil and water problems. Improved soil and water management practices will help to prevent and minimize mosquito sources.

Prolific production of mosquitoes may occur on the flat areas behind the Goshen Bay dike where return flows from irrigated areas will be collected and allowed to dissipate by evapo-transpiration.

Recommendations

Overall watershed management requires the cooperation of many interests to assure that development and activities will minimize the potential public health hazards. It is recommended that the following be given due consideration in development of the Central Utah Project.

General

1. That the water users' organization (i.e. Water Conservancy District) operating as the general administrative and contracting agency for the project should:

   a. Alert all water users of the potential public health hazards associated with using inadequately treated canal water for culinary purposes;

   b. Exert all possible precaution to exclude sewage effluents and barnyard drainage from project canals, laterals, and drains;

   c. Wherever and whenever possible assist the project inhabitants and communities in development of approved water and sewerage facilities;

   d. Operate and maintain project facilities in accordance with established criteria.

2. That potential recreational areas be investigated and at least minimum water and sanitary facilities be provided in accordance with Utah State Health Department regulations.

3. That a sanitary survey of proposed construction campsites be made and all camps be provided with water and sanitary facilities in accordance with Utah State Health Department regulations.

4. That recreational activities at reservoirs utilized as a source of public water supplies meet the requirements established by the Utah State Department of Health.

5. That person or persons responsible for a public water supply establish suitable controls over the use of watershed areas tributary to the supply to insure production of raw water meeting the quality requirements established by the Utah State Department of Health.

6. That all efforts be extended during construction stages, including land leveling and clearing, to exclude excess silt and debris from all water courses.

7. That the Utah State Department of Health be kept currently informed regarding changes in plans and proposed construction schedules so that guidance and consultation may be provided on items of public health significance.

Insect Vector Control

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. The agency, group, or individuals responsible for various aspects of the Central Utah Project should therefore be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation, or maintenance of the project. To minimize the public health hazards all effort should be made to avoid creating conditions which will increase population of mosquitoes and other arthropods and rodents of public health importance. It is recommended that the following principles and practices be adhered to in the design, construction, operation and maintenance of the project.

Prevention and Source Reduction Measures

Mosquitoes and Other Aquatic Insects

A. Reservoirs

1. All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2. Prior to impoundage, the reservoir basins should be prepared as follows:

   a. The normal summer fluctuation zone of the permanent pool should be completely cleared except for isloated trees and sparse vegetation along abrupt shorelines or in the deeper portion of the pool which will be exposed to wave action.

   b. Borrow pits, depressions, marshes, and sloughs which will be flooded by the reservoir at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

   c. If the summer fluctuation zone of the permanent pool is limited to a few feet, consideration should be given to "building out" mosquito-producing areas by deepening and/or filling of the more extensive shallow water areas located within one and one-half miles of population groups or recreational areas. This would minimize the need for repetitive measures for controlling vegetation and mosquito production.

3. After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreational areas frequented by significant numbers of persons:

   a. All dense vegetation should be removed periodically from flat, protected areas within the normal summer fluctuation zone of the permanent pool.

   b. Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

   c. Drains should be installed to adequately drain seepage areas that develop below the dam.

4. Water level management to minimize conditions favorable for mosquito production should be used to the maximum degree permitted by the primary purposes of the reservoirs. This will minimize the need for repetitive measures for controlling vegetation and mosquito production.

5. As a general principle, waterside recreational areas, particularly those which have facilities for overnight human occupancy, should be located along sections of reservoirs which have a low production potential for mosquitoes and other aquatic insects.

B. Irrigation Conveyance and Distribution System

1. Lining or other satisfactory seepage control measures should be provided for all sections of canals and laterals located in porous material where excessive leakage would result in waterlogged areas, seeps and ponds.

2. Drains should be installed to prevent ponding of excess irrigation water and natural runoff along the upper side of canals and laterals. All drainage crossing or inlet structures should be placed on grade to avoid ponding.

3. Borrow areas should be self-draining to keep them from retaining ponded water.

4. Where possible, provision should be made to prevent turnouts and other hydraulic structures from retaining residual water when they are not being used.

5. Effective measures should be provided to prevent ponding of leakage from water control structures.

6. Every effort should be made to establish delivery schedules which will provide farmers with adequate but not excessive amounts of water at proper intervals to insure efficient irrigation of the crops concerned.

7. Vegetation and debris which would retard normal flows should be periodically removed from conveyance channels, water control structures, and drains.

C. Project Drainage System

1. Trunk drainage systems should be installed to insure complete removal and proper disposal of excess irrigation water, natural runoff, and seepage from both irrigable and nonirrigable lands affected by the distribution and use of irrigation water on the project.

2. Drainage ditches should be designed, constructed, and maintained so as to minimize ponding in the channels and to insure free flows at all times.

3. Provision should be made to prevent water from ponding behind spoil banks.

4. Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.

5. Special provision should be made to prevent return flows from the Nosida area and other irrigated lands from being discharged onto the flat areas of Goshen Bay and dissipated by evapotranspiration. Since it has been determined that it would not be feasible to pump these return flows into Utah Lake, consideration might be given to providing collection channels that would discharge the water into the pond behind the dike. Bureau of Sport Fisheries and Wildlife is considering use of this water in a potential state waterfowl management area.

D. Irrigated Farms

1. The sponsoring agency and other organizations concerned with irrigation agriculture should do everything possible to encourage irrigation farmers to use the following irrigation and drainage practices which will prevent or minimize mosquito sources:

a. The farm supply system, drainage system, and field layouts should be properly fitted to the topography, soil, water supply, crops to be grown, and irrigation methods to be used.

b. All surface irrigated fields should be properly leveled or graded to provide for efficient water application and removal of excess water without ponding.

c. An adequate drainage system should be provided for removal of excess water from all portions of the farm.

d. Irrigation methods should be used which will provide optimum irrigation efficiencies.

e. Application of irrigation water should be limited to that required to fill the crop root zone plus unavoidable losses and excess water to prevent upward movement of salts.

E. Waterfowl Impoundments (Goshen Bay and Benjamin Slough areas)

1. Borrow areas resulting from construction of the impoundments should be located where they will be permanently inundated during the mosquito production season, if possible.

2. The shoreline margins of the impoundments should be steep-sided.

3. Adequate control structures should be provided to permit water level manipulation in the impoundments.

4. The impoundments should be designed and constructed so that a minimum water depth of two feet can be maintained during the mosquito-production season.

5. There should be close and continuous working relationships between the local and State health agencies and the Utah State Fish and Game Department with regard to the design, construction, and operation of the waterfowl impoundments.

Terrestrial Arthropods and Rodents at Recereational Areas Associated with Reservoirs

1. Proper storage, collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

2. All buildings should be rodent-proofed at recreational areas where rodents are prevalent which may create public health hazards.

3. Debris, rubbish, and other materials which may serve as haborage for rodents and other small mammals should be removed periodically.

4. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infection.

Supplemental Chemical Control Measures

In situations where adequate vector control is not obtained through the prevention and source reduction measures outlined above, provision should be made for supplemental use of insecticides and rodenticides to achieve the desired level of control.

Vector Appraisal

Arrangements should be made for carrying out a routine vector appraisal program as a part of normal operations at the reservoirs and the recreational areas associated with them. Inspections for adult and larval mosquitoes and other vectors are essential for planning and evaluating control measures and for adjusting control programs to meet temporary or emergency situations.

II. PUBLIC HEALTH AND RELATED PROBLEMS

Public Health Services

Project development will improve the economy of the area so that local residents benefiting either directly or indirectly will be in a position to enjoy a higher standard of living. Among other necessities, this involves the establishment of a healthful environment. Some of the more important factors in creating such an environment include the development of safe and ample culinary water supplies, proper waste disposal facilities, and insect and rodent control measures.

Public health services are provided in the project area by the Utah State Department of Health.

Recreational Development

Concomitant with the development of water resources comes the increased use of lands adjoining reservoirs for recreational purposes. This presents major problems of sanitation involving those of coordination of the multiple use policy and prevention of water pollution. The extent of recreational development, planned or spontaneous, immediately contiguous to reservoirs will be partially regulated by the topographical features of the shoreline. Also a receding shoreline during the irrigation season, together with an accumulation of mud deposits above the water level, will create hazardous and undesirable conditions for some water-based recreational activities.*

Construction Phase of Project

Limited housing accommodations are available in the vicinity of construction sites in the Uinta Basin to serve the contractor's employees during the construction phase of the project. Under these conditions a temporary construction camp may be necessary. Prior to selection of a camp site a sanitary survey of the proposed area should be made by the State Department of Health or the Public Health Service to assist in solving of problems which may be encountered in connection with the installation of water and sanitary facilities.

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*August 6, 1959, the Utah State Board of Health unanimously adopted the following:

"The State Department of Health recommends against swimming in streams and impoundments in the State of Utah, since their facilities do not lend themselves to proper protective control under conditions of utilization for public swimming purposes. Public swimming should be restricted to properly designed and operated artificial swimming pools."

Water supplies and sanitary facilities required in connection with temporary construction camps and with permanent housing for reservoir attendants should comply with the requirements of the Utah State Department of Health so as to eliminate potential health hazards.

Sanitary Aspects of Watershed Management

As overall watershed management involves many interests, it is considered essential that proposed developments and activities on watersheds pertaining to public health aspects be fully coordinated with State and/or local health departments. These matters should be mutually considered prior to the actual development of the watershed and issuance of permits.

Adequate and safe water and sanitary waste disposal facilities, in accordance with State and/or local health agency standards, should be provided in public use areas to serve camping, picknicking, and other recreational uses. Water and sanitary facilities for private dwelling sites should also meet the established health standards. The effectiveness of the sanitation program should be evaluated periodically by a detailed sanitary survey in conjunction with laboratory analyses of water samples collected from surface and/or ground water in the watershed.

On reservoirs constructed primarily to serve as a source for a municipal water supply, extreme caution should be exercised in considering recreational use of the reservoir. This also involves the possibility of additional pollution entering the water supply and the matter of aesthetics.

Mosquito and Other Vector Problems

Public Health and Socio-Economic Importance

Mosquitoes are the principal vectors which might be affected by the proposed project. Several species of mosquitoes of public health importance may be produced in large numbers in the general project area when suitable aquatic habitats are present. Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States and the area in which the proposed project will be located. Mosquitoes transmit the encephalitis viruses among birds and from them to humans and horses. There are no effective chemotherapeutic measures for preventing or treating human cases, and some individuals, particularly children, who recover from encephalitis often suffer permanent mental disability.

In past years, outbreaks of encephalitis have occurred among both horses and humans in several areas of central and northern Utah. Records of the U. S. Department of Agriculture show that equine encephalitis cases occurred in Utah County, Utah, during 13 years of the 17-year period, 1939 through 1955, for which records are available. During 4 of these years, this county had an incidence in excess of 5 encephalitis cases per 1,000 horses. Equine encephalitis cases were reported in Duchesne County, Utah, during 5 years of the 17-year period noted above, and in 2 of these years the incidence of the disease was in excess of 5 cases per 1,000 horses.

The most recent epidemic of encephalitis involving both horses and humans, occurred in Utah during the late summer and fall of 1958 and was centered in an area about 75 miles north of Utah County. This epidemic, involving 48 laboratory-confirmed human cases, was the largest outbreak of this disease among humans in the history of the State.

Entomological investigations during the decade 1948-58 have shown that Culex tarsalis and Culex pipiens, primary vectors of encephalitis, are prevalent mosquitoes in Utah and Duchesne counties. Production of these mosquitoes occurs in a wide range of aquatic habitats in both foul and fresh water. Aquatic habitats associated with irrigation are especially favorable for the production of C. tarsalis. These habitats include both semipermanent and permanent bodies of water such as flooded depressions on fields, roadside ditches, flooded wasteland, and seepage areas.

Several species of vicious-biting Aedes mosquitoes, including A. dorsalis and A. vexans, also occur in the general project area. Large numbers of these mosquitoes may create public health problems by interfering with the healthful outdoor activities of both children and adults during the summer months. Individuals, particularly children, frequently require medical attention and sometimes hospitalization for treatment of secondary infections and allergic reactions resulting from mosquito bites. The Aedes mosquitoes may be produced in temporary surface pools associated with irrigation and in ponds and reservoirs which have shallow vegetated areas subject to fluctuating water levels. Overflow pools along streams and other temporary surface pools also provide favorable larval habitats for several species of the highly pestiferous Aedes mosquitoes.

In addition to their public health importance, large numbers of biting mosquitoes also cause severe economic losses by lowering meat and milk production, by reducing the efficiency of agricultural and industrial workers, by interfering with recreational enterprises, and by lowering the value of real estate.

Several other groups of aquatic insects may be produced in habitats associated with water resource projects in sufficient numbers to create public health and economic problems. Deer flies and horse flies are often produced along the margins of impoundments and in seeps and marshes in irrigated areas. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of diseases such as tularemia and anthrax. Several species of small gnats of the family Heleidae are vicious biters and often produce severe reactions and vesicular lesions. These gnats are produced in damp areas of many irrigated valleys as well as alkaline marshes and other wetland areas. Black flies plague both man and livestock with their irritating and painful bites. They normally breed in fast-flowing streams, but are sometimes produced in large numbers in irrigation conveyance systems, particularly drop structures and other water control devices where the flow is relatively fast.

Vectors of terrestrial origin, including arthropods such as ticks, mites, fleas, and flies, and rodents such as ground squirrels, chipmunks, rats, and mice, may be important at recreational sites along the shores of reservoirs. In addition to the irritation, discomfort, and annoyance caused by the arthropod bites, the public health importance of these vectors involves a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, relapsing fever, tick paralysis, dysentery, typhoid, tularemia, typhus, and plague.

General Relationships Between Irrigation and Vector Problems

The production of mosquitoes and other aquatic insects of public health importance occurs in many irrigation areas. Natural breeding places are present in most irrigated areas, but usually man-made mosquito sources are far more important. These man-made aquatic habitats are frequently caused by the same faulty irrigation and drainage practices that result in serious soil and water problems such as excessive water losses, waterlogging, erosion, salt and alkali accumulations, damage to soil structure, leaching of plant nutrients, and reduced crop yields. Mosquito sources commonly associated with irrigation may be grouped into three principal categories: (1) those related to storage reservoirs; (2) those related to irrigation conveyance systems; and (3) those related to use of irrigation water on the farm and the disposal of excess water.

The conditions associated with storage reservoirs which are conducive to mosquito production include emergent vegetation and/or flotage and debris in shallow water areas and embayments that are protected from wave action; undrained depressions, borrow pits, sloughs, and swamps within the fluctuation zone; rising or constant pool levels which cause the water to remain in the marginal vegetation for more than four or five consecutive days during the mosquito breeding season; and marshy seeps below dams. It is generally difficult to control mosquito production on a reservoir that has not been properly prepared prior to impoundage.

The principal preimpoundage preparation measures for mosquito control include clearing of the reservoir basin; final removal of vegetation from the fluctuation zone prior to impounding; and drainage for depressions, sloughs, and swamps within the summer fluctuation zone. Of paramount importance is the fact that the maximum benefits from water level management for mosquito control can be realized only when the reservoir has been properly prepared. Several phases of water level control, particularly flood surcharge, constant level pool, and cyclical fluctuation and/or seasonal recession can sometimes be adapted to irrigation storage reservoirs in order to minimize conditions favorable for mosquito production. A particular phase may be used primarily to destroy mosquito larvae, or it may be directed at vegetation or flotage favorable for mosquito production. A flood surcharge above the upper normal pool level for a few days in the spring prior to the mosquito breeding season followed by a sharp drawdown is effective in stranding objectionable flotage. The invasion of marginal vegetation can be limited by holding the reservoir at a constant level during the early spring growth period. This phase is especially important since it will increase the effectiveness of subsequent fluctuation or recession. Seasonal water level recession used alone or in combination with periodic fluctuation is a very effective control measure since it provides a clean shoreline which is unfavorable for mosquito production. On many irrigation reservoirs, the normal water level recession which occurs throughout the summer months provides adequate mosquito control.

When unlined irrigation canals and laterals are constructed in pervious material, a large percentage of the water is lost by seepage through the beds and banks. In areas with poor underdrainage, these seepage losses, in combination with deep percolation from irrigated lands, often result in marshy seeps and ponded water in roadside ditches, borrow pits, and numerous other undrained depressions. Such aquatic habitats may occur on both irrigable and nonirrigable lands and produce tremendous numbers of mosquitoes, especially C. tarsalis, the common encephalitis vector. Large numbers of Aedes mosquitoes may be produced in seepage areas that have fluctuating water levels. In addition to creating conditions favorable for prolific mosquito production, seepage causes excessive loss of irrigation water and serious damage to valuable agricultural lands. Mosquitoes are also produced in various other types of ponded water areas associated with irrigation conveyance systems. Typical examples are ponded areas where canals block natural drainage ways,

residual water in turnout structure, stilling basins and other hydraulic structures, and pools caused by leakage from turnouts and other water control structures. Although such habitats are generally of minor importance in comparison with those caused by seepage and the numerous other breeding places that occur in irrigated areas, they do contribute to the overall mosquito problem.

In many irrigated areas, the most important mosquito sources are those associated with the use of water on the farm and the disposal of excess water. Studies on several operating irrigation projects in western states have shown that mosquito sources in this category are usually caused by poor irrigation and drainage practices that also result in serious agricultural problems, including reduced crop yields. These practices include inadequate land preparation; use of field layouts and irrigation methods that do not fit land, crops, and water supply; application of water in excess of crop requirements; inadequate drainage systems for disposal of excess water; and poor maintenance of distribution and drainage systems. All of these practices contribute to the development of both "on-field" and "off-field" aquatic habitats which are favorable for prolific mosquito production. Permanent and semipermanent aquatic habitats produce large numbers of C. tarsalis, and intermittently flooded areas produce tremendous numbers of Aedes mosquitoes.

Mosquito sources on irrigated fields have been found to occur most often on those used for pastures, hay meadows, and other close-growing crops. In order for the aquatic stages to mature and produce adult mosquitoes, ponded water must be present for at least four or five days. Observations in several irrigated areas have shown that when water is ponded on fields long enough to produce mosquitoes, the better forage grasses and legumes are frequently killed and replaced by undesirable wetland plants.

Heavy mosquito production also occurs in numerous "off-field" aquatic habitats. Many of the mosquito sources located outside irrigated fields are caused by improper disposal of excess water. Roadside ditches, borrow pits, depressions on wasteland, and numerous other undrained areas are flooded by excess irrigation water when farm and trunk drainage systems are inadequate. Such habitats produce large numbers of C. tarsalis and other mosquitoes of public health importance.

Anticipated Effects of the Proposed Project on Vector Problems

Portions of the reservoirs that have steep shores with little or no vegetation and are exposed to wave action will be unfavorable for the production of mosquitoes and other aquatic insects of public health importance and will require no special vector prevention or

control measures. Mosquitoes and other aquatic insects of public health importance may be produced in tributary embayments and other marginal areas of the reservoirs where the topography is flat and the water is shallow, protected from wave action, and contains emergent vegetation or flotage. In such areas appropriate measures for prevention and control of aquatic vectors should be provided. The development of recreational and other public use areas at various locations along the shores of the reservoirs may result in the exposure of humans to vectors of terrestrial origin including arthropods such as ticks, fleas, and flies, and rodents such as ground squirrels, chipmunks, mice, and rats. In order to minimize public health hazards at waterside recreational areas, appropriate prevention and control measures for both aquatic and terrestrial vectors should be carried out.

Entomological surveys have shown that numerous mosquito-producing habitats exist throughout the presently irrigated areas of the proposed project. Many of these existing mosquito sources are directly related to seepage and inadequate drainage for the removal of excess irrigation water. In addition, poor irrigation and drainage practices employed by the water users result in widespread conditions which are highly favorable for mosquito production. The provision of more water for lands presently under irrigation and the development of additional irrigated areas may aggravate existing mosquito sources and create new aquatic habitats favorable for the production of mosquitoes unless appropriate prevention and control measures are built into the project and continued as a part of the regular operation and maintenance programs. Leakage from unlined canals and laterals may cause existing seepage areas to increase in size and new ones to appear unless seepage prevention and control measures are provided. Seepage from irrigated lands at higher elevations and runoff from irrigated lands may aggravate existing or create new mosquito sources unless adequate drainage systems are installed.

Under present operations, Utah Lake results in conditions which are favorable for mosquito production. Marginal flat areas containing salt grass and other vegetation are flooded during the early part of the season when the lake is at the higher pool levels. The shallow flooding of these marginal areas provides conditions favorable for mosquito production. Extensive shallow marginal areas of this type occur in Provo and Goshen Bays. Even at lower lake levels later in the season, heavy winds may cause the lake water to flood flat marginal areas. When the lake recedes, isolated marginal pools are left in which mosquitoes may be produced. In addition to these conditions associated with present lake operations, numerous mosquito sources occur in the flat fringe areas above compromise level of the lake (the approximate normal high water level of the lake under present operations) in the Provo and Goshen Bays. These mosquito sources include seepage areas and depressions and other undrained areas that are flooded by natural runoff and excess irrigation water. Many of these habitats produce mosquitoes throughout the season.

Under the proposed plan of development for Provo Bay, the bay area would be diked off from the rest of the lake and the arable lands within the bay below compromise level and adjacent arable lands in the fringe area above compromise level would be reclaimed for irrigation farming. This would completely eliminate mosquito-producing conditions in the bay area that are associated with present operation of Utah Lake. Reclamation and drainage of the fringe areas in Provo Bay would also eliminate numerous other mosquito sources. In addition, the drains which would be installed in the Provo Bay area would provide outlets for future drainage of mosquito sources located on nonirrigable lands. Thus, the proposed plan of development for Provo Bay would be of great benefit from the standpoint of mosquito prevention and control.

Under the proposed plan of development for Goshen Bay, the bay area would be diked off from the rest of the lake and the high evapo-transpiration losses in the bay area under present lake conditions would be substantially reduced. Lands in the Goshen Bay area are not suitable for reclaiming for irrigation farming. Owing to the poor chemical quality of the present local surface and ground water inflows to the bay and the return flows from the new irrigated lands in the Mosida area these inflows along with the precipitation in the bay area would be consumed by evapo-transpiration in the bay area behind the dike. No provision would be made for drainage in the bay area to collect and salvage this water by pumping it into Utah Lake. After construction of the dike and equilibrium becomes established, it is anticipated that these inflows and the precipitation will create a pond of undetermined size behind the Goshen Bay Dike. It is believed that except during unusual floods the area of this pond will be far less than the area of Goshen Bay (about 27,000 acres) when the lake is at compromise level. An emergency spillway would probably be constructed at the east end of the Goshen Bay Dike to provide for spilling lake water into the bay area during extreme flood conditions.

Except during extreme flood conditions when the Goshen Bay area would be flooded, it is anticipated that the acreage of flat marginal areas suitable for mosquito production around the pond behind the Goshen Bay Dike would be considerably less than that associated with Goshen Bay under present lake operations. Entomological studies in the Goshen Bay area by personnel of the Utah County Health Department have shown that widespread mosquito sources occur in the flat fringe areas above compromise level of the lake. These mosquito sources include seepage areas, marshes, and numerous depressions that are flooded by thermal springs, natural runoff, and irrigation waste water. After construction of the Goshen Bay Dike, the return flows from new irrigated areas, together with precipitation in the bay area and possible increases in inflows from ground water, may result in an increase in the extent of mosquito sources in the fringe areas above

compromise elevation and cause similar aquatic habitats to develop in the bay area below compromise elevation. At the present time it is not possible to determine the overall effects that the proposed Goshen Bay Development would have on mosquito production. Detailed studies should be made to determine the nature and extent of mosquito sources in the bay area under present lake operations. Similar studies should also be carried out after the dike has been constructed in order to evaluate the overall effects of the development on mosquito production.

Plans have been underway for several years to establish a mosquito abatement program in Utah County. It is possible that such a program might be in operation before the Goshen Bay Dike is constructed. Anything that might be done in connection with the Goshen Bay Development to minimize existing mosquito sources or to prevent the development of new aquatic habitats would reduce the cost of the mosquito control program.

It is understood that plans are being considered for the development of waterfowl impoundments, possibly in the Goshen Bay area or Benjamin Slough area, to replace aquatic wildlife habitats that will be eliminated by the Provo and Goshen Bay Developments. Some of the return flows from irrigated lands in the Mosida area might be collected by interceptor drains and diverted into the waterfowl impoundments. The collection of these return flows rather than allowing them to be dissipated by evapo-transpiration in the bay area should prevent the development of certain mosquito sources. Experience has shown that a properly constructed and managed waterfowl impoundment will produce only a fraction of the mosquitoes that would be produced in the same size area if it were subjected to uncontrolled flooding by excess irrigation water. The agencies concerned with mosquito control and waterfowl conservation should therefore cooperate in every way possible in the development and management of waterfowl impoundments that are constructed.

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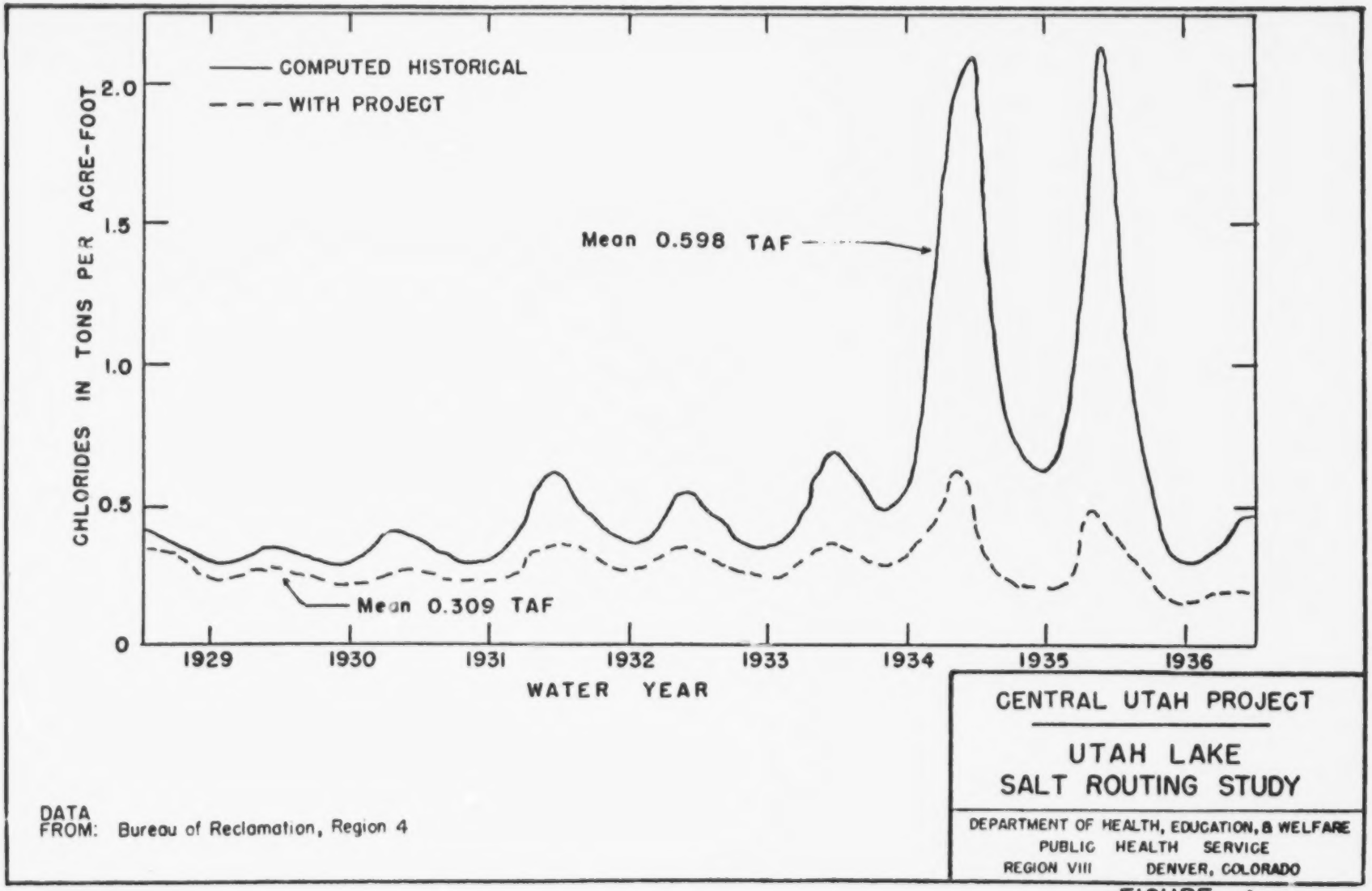


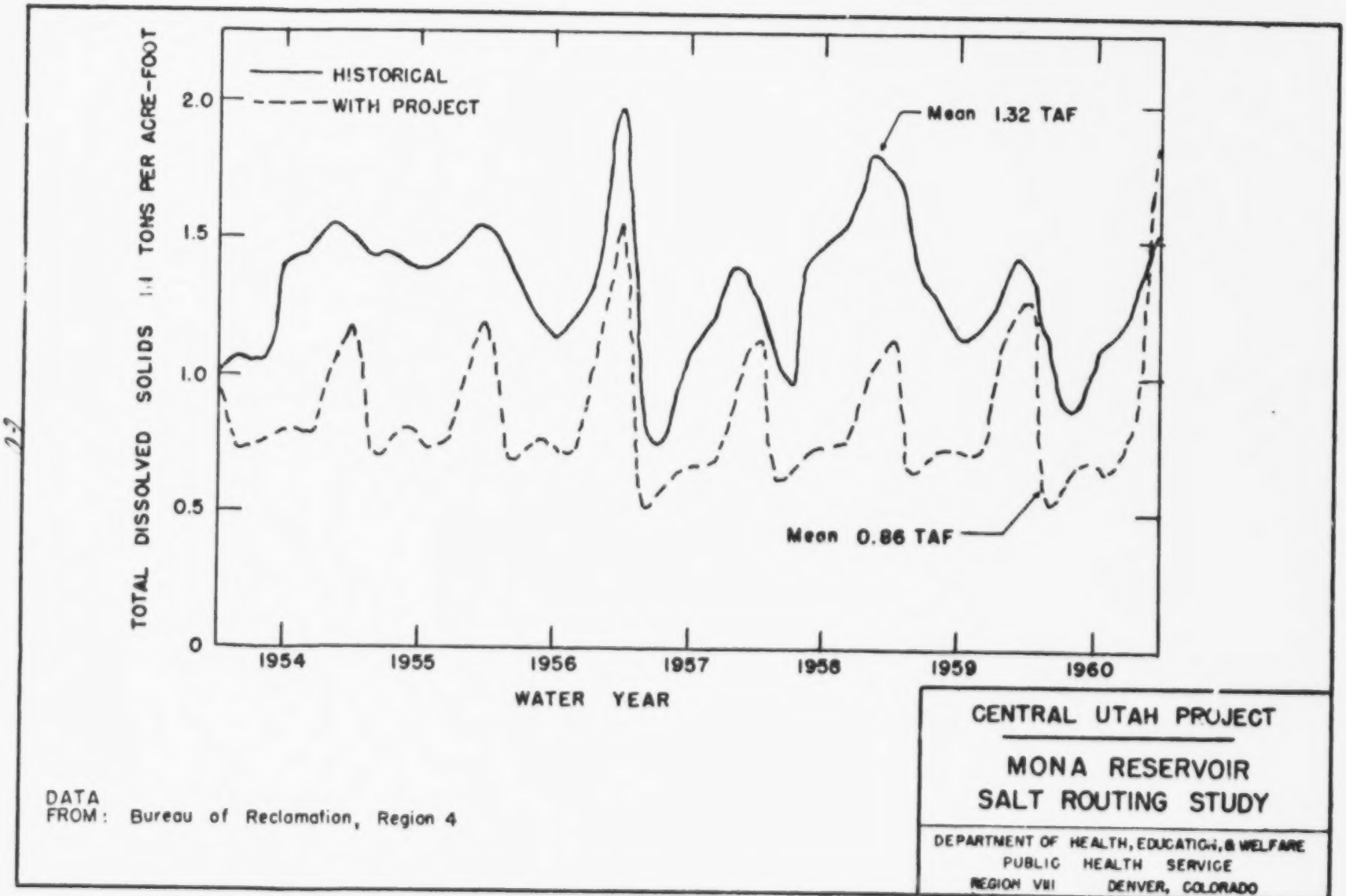
CENTRAL UTAH PROJECT

UTAH LAKE
SALT ROUTING STUDY

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

DATA
FROM: Bureau of Reclamation, Region 4

FIGURE A



DATA
FROM: Bureau of Reclamation, Region 4

CENTRAL UTAH PROJECT

MONA RESERVOIR
SALT ROUTING STUDY

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

FIGURE B

APPENDIX "B"

UTAH WATER POLLUTION CONTROL BOARD

THE STANDARDS OF QUALITY AND THE REGULATIONS FOR WATER CLASSIFICATION

Adopted by the Utah Water Pollution Control Board, November 19, 1954, and made official by order of the Board, February 24, 1955, pursuant to authority of Section 73-14-6, Utah Code Annotated, 1953 as amended by Session Laws of 1953. Amended by order of the Board, September 7, 1960.

Class "C" waters shall be so protected against pollution as to be suitable at all times for domestic water supplies which are treated before use by coagulation, sedimentation, filtration, and disinfection. Class "C" waters shall be suitable without treatment for irrigation, stock watering, fish and wildlife propagation, recreation (except swimming), as a source for industrial supplies, and for other uses, as may be determined by the Board.

Regulations & Standards: No person shall discharge into Class "C" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954, or

(3) which result in a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of the samples collected during any month; or in an MPN exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding 5 parts per million (ppm); or in a BOD exceeding this amount in more than 20% of the samples collected in any month; or in a BOD exceeding 10 ppm in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids or sludge deposits in said waters which are readily visible, or which result in an appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 5.0 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters injurious to fish life and waterfowl, or unsafe or unsuitable as sources of water supply for domestic use, food processing or industrial use, or unsuitable for agricultural purposes, stock watering, or recreation (except swimming).

The following notes were adopted as modifications to The Standards of Quality and the Regulations for Water Classification on September 7, 1960, and are hereby made a part of said standards and regulations.

NOTE 1: The Board may assign any one of the foregoing classifications to a given water notwithstanding the presence in said water of natural pollutants in excess of limits established by the classification, in which case the subscript "1" shall be added to the usual classification designation (A_1, B_1, C_1, etc.) to denote the modification of water quality. No change in waste discharge restrictions of the basic classification shall be inferred, except that the discharge of any wastes in such a way as to increase the concentration of any of the excessive natural pollutants in the classified water is prohibited.

NOTE 2: Wastes discharged to waters of the state under limitations imposed by a given classification shall be further controlled as required to protect water quality designated by all downstream classifications.